# The Nonlinear Effects of Fiscal Policy*

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**Abstract**

We argue that the fiscal multiplier of government purchases is nonlinear in the size of the spending shock. In particular, the multiplier is increasing in the spending shock, with more expansionary government spending shocks generating larger multipliers and more contractionary shocks generating smaller multipliers. We document that empirically this holds true across time, countries and types of shocks. We then propose a neoclassical mechanism that hinges on the relationship between fiscal shocks, their form of financing, and the response of labor supply across the wealth distribution. A neoclassical incomplete markets model predicts that the aggregate labor supply elasticity is increasing in the spending shock, and this holds regardless of whether shocks are deficit- or balanced-budget financed. We show this mechanism to still be the driving force of the nonlinear effects of fiscal policy in the presence of nominal price rigidities, and that a HANK model is able to quantitatively reproduce our empirical estimates for the size and range of the multiplier. We find evidence for our mechanism using micro-data for the US.

*Keywords*: Fiscal Multipliers, Nonlinearity, Asymmetry, Heterogeneous Agents
*JEL Classification*: E21; E62; H50

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# 1 Introduction

During the 2008-2009 financial crisis, many OECD countries adopted expansionary fiscal policies to stimulate economic activity. These fiscal expansions were often followed by austerity measures aimed at reducing the size of the resulting high levels of government debt (referred to as fiscal consolidations). This era of fiscal activism inspired the economic literature to revive the classical debate on the size of the fiscal multiplier and its determinants, such as the state of the economy, income and wealth inequality, demography, tax progressivity, and the stage of development, among others.[1] More recently, the COVID-19 crisis has forced many countries into unprecedented budget deficits; concerns about debt sustainability are likely spur consolidation programs of different sizes and forms of financing after the crisis.

Most of the literature on fiscal policy, however, treats the fiscal multiplier as one number: small and large shocks are assumed to have the same relative effects on output. In this paper, we argue that fiscal multipliers from government spending shocks depend on the size of the shock. Specifically, large negative shocks yield smaller multipliers, while large positive shocks yield larger multipliers. We first present empirical evidence of this pattern and then show that it can be generated by a standard calibrated neoclassical model with incomplete markets and heterogeneous agents. The key mechanism, which hinges on the differential response of labor supply across the wealth distribution, is robust to assumptions about the form of financing and survives the introduction of nominal rigidities in the context of a Heterogeneous Agents New Keynesian (HANK) model.

Applying the data and methodology from two well known empirical studies (Alesina et al. 2015a and Ramey and Zubairy 2018), we find evidence of the size dependence of fiscal multipliers across different time periods, countries, and modes of financing. In our

[1] See for example Auerbach and Gorodnichenko (2012), Ramey and Zubairy (2018), Brinca et al. (2016), Brinca et al. (2021), Hagedorn et al. (2019), Krueger et al. (2016), Basso and Rachedi (2021), Ferrière and Navarro (2018), Ilzetzki et al. (2013), and Faria-e-Castro (2024).

first empirical exercise we adapt the methodology and data of Alesina et al. (2015a), who use annual data on exogenous fiscal consolidation shocks (defined as policies aimed at reducing government debt) identified via a narrative approach, across 15 OECD countries over the 1981-2014 period. We find the multiplier to be significantly — both quantitatively and statistically — larger for smaller fiscal consolidation shocks, with the effect being stronger for unanticipated than for anticipated shocks. We also find the results to be similar across both spending- and tax-based fiscal consolidations.

In the second empirical exercise we borrow the data and methodology from Ramey and Zubairy (2018), who use quarterly data for the US economy going back to 1889 and an identification scheme for government spending shocks that combines news about forthcoming variations in military spending and the identification assumptions of Blanchard and Perotti (2002). Using the projection method of Jordà (2005), we find evidence that the fiscal multiplier depends on the size of the shock. This corroborates the finding that the multipliers of larger consolidations are smaller than those of smaller negative fiscal shocks.

We then show that these empirical findings can be rationalized in the context of a standard, neoclassical, heterogeneous agents model with incomplete markets, similar to Brinca et al. (2016) but with an infinite time horizon. The model is calibrated to match key features of the US economy, such as the income and wealth distributions, hours worked, and taxes. In our model, agents face uninunsurable labor income risk that induces precautionary savings behavior. The equilibrium features a positive mass of agents who are borrowing constrained: as is well known, the elasticity of intertemporal substitution (EIS) is increasing in wealth, with constrained agents having the lowest EIS.[2] Thus the labor supply elasticity of constrained and low-wealth agents is higher and their work hours are more responsive to contemporaneous changes in income. On the opposite, the hours worked of constrained and low-wealth agents are less responsive to

[2]See Domeij and Floden (2006) for the relationship between wealth and EIS of labor and Vissing-Jørgensen (2002) for the relationship between wealth and the EIS of consumption.

future income shocks. This model feature, combined with shifts of the wealth distribution, is prevalent in driving the nonlinear effects of fiscal policy, and we show that the mechanism survives even in the presence of nominal price rigidities.

We study how the economy responds to different types of government spending shocks: permanent or temporary, deficit-financed or balanced-budget financed. A decrease in government spending that leads to a reduction in government debt generates a positive future income effect, as capital crowds out government debt and increases real wages. This positive shock to future income induces agents to reduce savings today, raising the mass of agents at or close to the borrowing constraint. Since wealthier agents react more to shocks to future income, their labor supply falls by relatively more in response to this government spending shock. Combining these two forces delivers our result: larger debt consolidations leads to a larger increase in the mass of constrained agents, and these are the agents whose labor supply responds less to the shock. Therefore, larger fiscal consolidations (negative shocks to government spending) elicit a relatively smaller aggregate labor supply response, which results in a smaller fiscal multiplier. For increases in government spending financed by debt, the opposite is true: larger positive shocks induce larger labor supply responses and thus larger fiscal multipliers. We show that this mechanism holds for deficit-financed reductions in government spending, regardless of whether they are permanent or temporary.

We also show that balanced-budget government spending shocks result in the same pattern of sign and size dependence thanks to this mechanism. Consider the case of a fiscal contraction that is accompanied by a contemporary increase in transfers so that public debt is held constant: the contemporary positive income effect elicits a much larger labor supply response by constrained and low-wealth agents. This positive income effect increases agents' wealth and pushes some of them away from the borrowing limit. This rightward shift in the wealth distribution decreases the aggregate labor supply response, as agents further away from the constraint respond less than those at the constraint, resulting in a smaller response of output and a smaller fiscal multiplier. The larger the change in the transfer, the larger the shift in the wealth distribution and the larger the reduction in the aggregate labor supply elasticity and the fiscal multiplier. The opposite is true for fiscal expansions, contemporaneously financed by a decrease in lumpsum transfers: the negative income effect decreases agents' wealth and shifts the wealth distribution to the left, where agents have a stronger labor supply response, leading to a larger multiplier, the larger the size of the government spending shock.

We then show that our key mechanism, which relies on the differential response of labor supply across the wealth distribution and movements of thedistribution, survives the introduction of nominal rigidities. We repeat the same experiments in a state-of-the-art HANK model as in Auclert et al. (2021b), and find that nominal rigidities not only increase the level of the multiplier, but also its sensitivity to the size of the shock. The results and mechanism hold for both deficit-financed and balanced-budget fiscal experiments. We show that a version of the HANK model where the central bank reacts less to changes in inflation from its target, and where fiscal taxes/transfers do not adjust quickly to close deficits is able to reproduce the level and range of multipliers that we estimate in the data.

We conclude the paper by empirically testing the validity of our labor supply channel by inspecting micro-data. Using data from the Panel Study of Income Dynamics (PSID), we assess how the labor supply response to government spending shocks depends on wealth and how this relationship depends on the financing of the shock. We establish that for spending shocks that are financed through contemporary taxes/transfers, the labor supply response is strongest for poorer agents, while the response is stronger for wealthier agents when spending shocks are deficit-financed.

Our work is closely related to that of Krueger et al. (2016), Athreya et al. (2017), Ferrière and Navarro (2018), Auclert et al. (2021a), Andres et al. (2022), Basso and Rachedi (2021), Hagedorn et al. (2019), Brinca et al. (2016), Brinca et al. (2021) and Heathcote (2005) who also study the effects of fiscal policy in the context of incomplete markets models with heterogeneous agents. Our focus, however, is not on the state dependence of multipliers or on how different policies produce different multipliers, but rather on how the same type of policy — government spending — can generate fiscal multipliers that are size-dependent, regardless of the manner in which it is financed. Also related is the work of Cantore et al. (2022), who study how the effects of monetary policy interact with the labor supply of the left tail of the income distribution via a neoclassical mechanism that is based on wealth effects. Our study is complementary is theirs and focuses on a similar mechanism for fiscal policy.

The rest of the paper is organized as follows: Section 2 presents empirical evidence on size- and sign-dependent fiscal multipliers. Section 3 introduces the heterogeneous agents neoclassical model, and Section 4 describes our calibration strategy. Section 5 presents the results from the quantitative model. Section 6 introduces nominal prices rigidites in the neoclassical model and shows that the driving force of the nonlinear effects of fiscal policy is still the same. Section 7 empirically tests and validates the mechanism combining micro data from the PSID with data on government spending and debt. Section 8 concludes.

## 2 Empirical Evidence

In this section, we use two different empirical methodologies and datasets to document that larger fiscal shocks generate relatively larger effects on output, i.e. larger fiscal multipliers. We begin by presenting evidence from fiscal consolidation programs in 15 OECD countries, using the dataset from Alesina et al. (2015a). Second, we employ the methodology from Ramey and Zubairy (2018), who study fiscal multipliers using historical data for the US.

### 2.1 *Fiscal Consolidation Episodes*

Using the dataset of Alesina et al. (2015a), we show that larger fiscal consolidations (reductions of government debt) generate smaller fiscal multipliers. We show that this pattern is more evident for unanticipated fiscal shocks and applies both to revenue-based and spending-based fiscal consolidations.

The annual dataset of fiscal consolidation episodes includes 15 OECD countries and ranges from 1981 to 2014.[3] Alesina et al. (2015a) expand the original dataset of Pescatori et al. (2011) with exogenous fiscal consolidation episodes, known as IMF shocks. Pescatori et al. (2011) use the narrative approach of Romer and Romer (2010) to identify exogenous fiscal consolidations, i.e. consolidations driven uniquely by the desire to reduce budget deficits. The use of the narrative approach filters out all policy actions driven by the business cycle, ensuring that the identified consolidations are independent from the current state of the economy.

Besides expanding the dataset of Pescatori et al. (2011), Alesina et al. (2015a) use the methodological innovation introduced by Alesina et al. (2015b), who point out that a fiscal adjustment is a multi-year plan rather than an isolated change and consequently results in both unexpected policies and policies that are known in advance. Ignoring the link between both expected and unexpected policies may yield biased results.

Alesina et al. (2015a) define a fiscal consolidation as deviations of public expenditure relative to their level (in % of GDP) if no policy had been adopted plus expected revenue changes stemming from tax code revisions. Moreover, fiscal consolidations that were not implemented are not included in the dataset, and so all considered fiscal consolidation episodes are assumed to be fully credible.

To formally investigate the nonlinear impact of consolidation shocks on GDP, we use the local projection method of Jordà (2005) to estimate the following specification

[3]The dataset includes Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Japan, the United Kingdom, the US, Ireland, Italy, Portugal, and Sweden. As we only have data for Germany starting in 1991, we drop it from the baseline analysis. We then test and confirm that the results hold when including Germany, with the sample ranging from 1991 to 2014.

| Variable | h 0 | 1 | 2 |
|---|---|---|---|
| $\beta_1$ | -0.503*** | -1.174*** | -0.412** |
| | (0.154) | (0.203) | (0.161) |
| $\beta_2$ | 0.094** | 0.217*** | 0.082 |
| | (0.046) | (0.058) | (0.053) |
| Observations | 495 | 480 | 465 |
| Number of countries | 15 | 15 | 15 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 1:** Nonlinear effects of fiscal consolidation shocks at different horizons h.

at different horizons h, to test for the existence of nonlinear effects of the consolidation shocks:

$$\Delta y_{i,t+h} = \beta_1 e_{i,t} + \beta_2 (e_{i,t})^2 + \alpha_i + X_{t-1} + \gamma_t + \epsilon_{it} \tag{1}$$

where $\Delta y_{i,t+h}$ and $e_{i,t}$ are the output growth rate and the fiscal consolidation shock in % of GDP, respectively, in country $i$ and year $t$. $X_{t-1}$ is a vector of lagged control variables, including output growth rate and the fiscal consolidation shocks. $\alpha_i$ and $\gamma_t$ are country- and time-level fixed effects, respectively. We include the squared term of the fiscal consolidation shocks $(e_{i,t})^2$ to capture the nonlinear effects of fiscal shocks. To account for simultaneous cross-country correlations of the residuals, we estimate equation (1) using the generalized least-squares method and controlling for heteroskedasticity. To control for the effects of outliers, we winsorize output variations at the 5th and 95th percentiles.

The coefficients reported in Table 1 capture the negative effect of consolidation shocks on output, with $\beta_1$ being negative and statistically significant. $\beta_2$ is positive and significant, which illustrates the nonlinear effect of consolidation shocks on output: larger consolidations generate relatively smaller effects on output, i.e., smaller fiscal multipliers.[4] Not only is $\beta_2$ statistically significant but is also economically meaningful. Going

[4]Notice the fiscal multiplier is given by $\beta_1 + 2 \times \beta_2 \times e_{it}$. If $\beta_2$ was zero, the multiplier would be constant and equal to $\beta_1$.

| | h | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Multiplier 0% | 0.503 | 1.174 | 0.412 |
| Multiplier -0.5% | 0.409 | 0.957 | 0.330 |
| Multiplier -1.5% | 0.221 | 0.523 | 0.166 |

**Table 2:** Fiscal consolidation multipliers for different shocks at different horizons h.

from a marginal to a 1.5% of GDP consolidation decreases the multiplier on impact by 50%, as can be seen in Table 2. Moreover, the nonlinear effects are persistent, and are still present one year after the shock.

Table 12 in A.1 compares the non-linear effects of both unanticipated and anticipated shocks. The main driver of the non-linear effects are the unanticipated shocks, with the quadratic term not being significant for anticipated shocks.

### 2.1.1 Financing Instrument

We also test if it matters whether consolidations are consumption-, transfer- or tax-based. Tables 13-15 in the appendix report the average consolidation shocks during transfer, consumption and tax based consolidations.[5] We have in total 211 consolidation episodes, with 63 being classified as transfer, 71 as consumption and 77 as tax based consolidations.

Using the three different consolidation types, we estimate the following specification:

$$\Delta y_{i,t+h} = \beta_1^G e_{i,t}^G + \beta_2^G (e_{i,t}^G)^2 + \beta_1^g e_{i,t}^g + \beta_2^g (e_{i,t}^g)^2 + \beta_1^t e_{i,t}^t + \beta_2^t (e_{i,t}^t)^2 + X_{t-1} + \alpha_i + \gamma_t + \epsilon_{it}$$

where $e_{i,t}^G$, $e_{i,t}^g$ and $e_{i,t}^t$ are the consumption, transfer, and tax-based consolidation shocks. The coefficients are reported in Table 3 and establish that the quadratic terms for both consumption and tax based (unanticipated) consolidations – $\beta_2$ and $\beta_6$, respectively – are positive and statistically significant on impact, and persist over the next two years. More-

[5] We follow the Alesina et al. (2015a) consolidation classification. A consolidation is classified as a tax, transfer, or consumption consolidation depending on the largest component out of the three for the horizon of the consolidation plan.

over, both coefficients are economically meaningful on impact. Going from a marginal to a 1.5% of GDP consolidation decreases the multiplier for G and t consolidations by 119% and 88%, respectively, as reported in Table 11 in A.1

| | h | | |
|---|---|---|---|
| Variable | 0 | 1 | 2 |
| $\beta_1^G$ | -1.011*** | -2.009*** | -0.613** |
| | (0.274) | (0.297) | (0.290) |
| $\beta_2^G$ | 0.401*** | 0.573*** | 0.201** |
| | (0.093) | (0.097) | (0.098) |
| $\beta_1^g$ | 0.250 | -0.494* | -0.011 |
| | (0.255) | (0.267) | (0.190) |
| $\beta_2^g$ | 0.020 | 0.121* | -0.041 |
| | (0.063) | (0.065) | (0.061) |
| $\beta_1^t$ | -0.975*** | -1.915*** | -1.504*** |
| | (0.317) | (0.331) | (0.287) |
| $\beta_2^t$ | 0.286** | 0.337*** | 0.390*** |
| | (0.122) | (0.126) | (0.115) |
| Observations | 495 | 480 | 465 |
| Number of countries | 15 | 15 | 15 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 3:** Non-linear effects of fiscal unanticipated consumption, transfers and taxed based consolidation shocks, including controls.

Table 16 in A.1 shows that our results are robust to the inclusion of previously announced consolidation-plans implemented at time t. Finally, Tables 17 to 18 show that our results are robust to (i) including Germany and (ii) restricting the sample to the 1991-2014 period.

### 2.2 *US Historical Data*

We continue to investigate the relationship between the fiscal multiplier and the size of the underlying fiscal shock by employing the methodology and the historical dataset constructed by Ramey and Zubairy (2018), which contains quarterly time series for the US economy ranging from 1951 to 2015.[6] The dataset includes real GDP, the GDP de-

[6] We focus on the post-1951 period to ensure that our results are not driven by three major wars: WWI, WWII and the Korean War.

flator, government purchases, federal government receipts, population, unemployment rates, interest rates, and defense news. Quarterly US historical data provides us with a long enough time series to compare the multipliers across fiscal shocks of different sizes, as well as many periods of expansion and recession, and different regimes for fiscal and monetary policy.

To identify exogenous government spending shocks, Ramey and Zubairy (2018) use two different approaches: (i) a defense news series proposed by Ramey (2011), which consists of exogenous variations in government spending linked to political and military events that are identified using a narrative approach and that are plausibly independent from the state of the economy, and (ii) shocks based on the identification hypothesis of Blanchard and Perotti (2002) that government spending does not react to changes in macroeconomic variables within the same quarter. Ramey and Zubairy (2018) argue that the Blanchard-Perotti (BP) shock is highly relevant in the short run (since it is the part of government spending not explained by lagged control variables), while defense news data are more relevant in the long run (as news happen several quarters before the spending actually occurs). As we are more interested in short run dynamics of fiscal policy, we focus on the BP shocks on our application.

To test for the nonlinear effects of the fiscal shock, we expand the linear regression as in Ramey and Zubairy (2018) with a quadratic term of the fiscal shock, which is then estimated using the local projection method of Jordà (2005). Formally, this method consists of estimating the following equation for different time horizons $h$:

$$x_{t+h} = \alpha_h + \Psi_h(L) z_{t-1} + \beta_h^x \text{shock}_t + \beta_{2,h}^x \left(\text{shock}_t\right)^2 + \epsilon_{t+h}, \text{ for } h = 0, 1, 2, ... \tag{2}$$

where $x$ is either real GDP per capita $y$ or government spending $g$, both divided by trend GDP, and $z$ is a vector of lagged control variables, including real GDP per capita, government spending, and tax revenues (all divided by trend GDP). $\Psi_h(L)$ is a polynomial of order four in the lag operator, and $\text{shock}_t$ is the BP spending shock.

Ramey and Zubairy (2018) argue that in a dynamic environment the multiplier should not be calculated merely as the peak of the output response to the initial government spending variation but rather as the integral of the output variation to the integral of the government spending variation, Mountford and Uhlig (2009); Uhlig (2010); Fisher and Peters (2010). This method has the advantage of measuring all the GDP gains in response to government spending variations in a given period. To calculate the cumulative multiplier we proceed in three steps: 1) estimate the output response to the fiscal shock, using equation (2); 2) estimate the government spending response to the fiscal shock using equation (2); 3) divide the output response by the government spending response.[7] The cumulative multiplier is then given by

$$\frac{\sum_{j=0}^{h} \frac{\partial y_{t+j}}{shock_t}}{\sum_{j=0}^{h} \frac{\partial g_{t+j}}{shock_t}} = \frac{\sum_{j=0}^{h} \beta_h^y + 2\beta_{2,h}^y \text{shock}}{\sum_{j=0}^{h} \beta_h^g + 2\beta_{2,h}^g \text{shock}}. \tag{3}$$

This three-step method produces points estimates for the fiscal multipliers, but not standard errors. We compute the standard errors for the fiscal multipliers using bootstrap methods. These allow us to generate distributions for the estimated multipliers, from where we can compute averages and standard deviations for each horizon $h$.

Table 4 presents the cumulative fiscal multipliers at horizons from 0 to 12 quarters and for five different shocks,in percentage of GDP: -1.5%, -0.5%, the marginal multiplier at a 0% shock, +0.5% and +1.5%. In the absence of size-dependence, fiscal multipliers should be approximately the same regardless of the fiscal shock. The results suggest otherwise, and are in line with the ones presented in section 2.1. The impact multiplier (at $h = 0$) already presents economically meaningful differences: going from the marginal multiplier of a 0% shock to a shock equal to 1.5% of GDP increases the fiscal multiplier

[7]For the linear case, Ramey and Zubairy (2018) propose a one step approach which yields the same results as the three step approach. For the quadratic case, the one step approach and the three step are no longer equivalent.

| Horizon/Shock | -1.5% | -0.5% | 0% | +0.5% | +1.5% |
|---|---|---|---|---|---|
| 0 | -0.041 | 0.610 | 0.820 | 0.991 | 1.255 |
| | ( 0.857) | ( 0.237) | ( 0.138) | ( 0.195) | ( 0.405) |
| 1 | -0.829 | 0.356 | 0.831 | 1.251 | 1.966 |
| | ( 0.561) | ( 0.181) | ( 0.129) | ( 0.199) | ( 0.402) |
| 2 | -1.412 | 0.359 | 1.002 | 1.540 | 2.394 |
| | ( 0.733) | ( 0.230) | ( 0.136) | ( 0.186) | ( 0.376) |
| 3 | -0.965 | 0.322 | 0.913 | 1.478 | 2.548 |
| | ( 0.528) | ( 0.201) | ( 0.115) | ( 0.168) | ( 0.434) |
| 4 | -1.173 | 0.214 | 0.870 | 1.505 | 2.726 |
| | ( 0.353) | ( 0.145) | ( 0.105) | ( 0.135) | ( 0.295) |
| 8 | 0.327 | 0.789 | 1.027 | 1.272 | 1.782 |
| | ( 0.236) | ( 0.108) | ( 0.068) | ( 0.091) | ( 0.231) |
| 12 | 0.879 | 1.028 | 1.106 | 1.187 | 1.358 |
| | ( 0.211) | ( 0.086) | ( 0.044) | ( 0.079) | ( 0.222) |

**Table 4:** Estimated cumulative multipliers for fiscal shocks of different sizes (columns) at different horizons (rows). Bootstrap standard errors in parentheses.

by more that 50%. One year after the initial shock the differences are even larger: going from a 0% to a 1.5% shock increases the multiplier by a factor of 3.

Figure 1 plots the cumulative multipliers for the different time horizons, together with the 95th confidence intervals. The figure illustrates that the non-linearity is not only economically meaningful but also statistically different from each others.

Finally, we show in A.2 that our results are robust to changing several assumptions. First, we include taxes as a control variable. [8] Second, we include both a linear and a quadratic trend. Third, we include a polynomial of order eight in the lag operator instead of order four. Results can be found in Figures 16-18 in A.2.

[8] Ferrière and Navarro (2018) show that the response of taxes is an important determinant of the size of the fiscal multiplier. By controlling for taxes, we show that the nonlinear effect is independent of the taxes. Additionally, in section 2.1, we show the results to be robust to tax consolidations and to government consumption consolidations, controlling for the path of taxes.

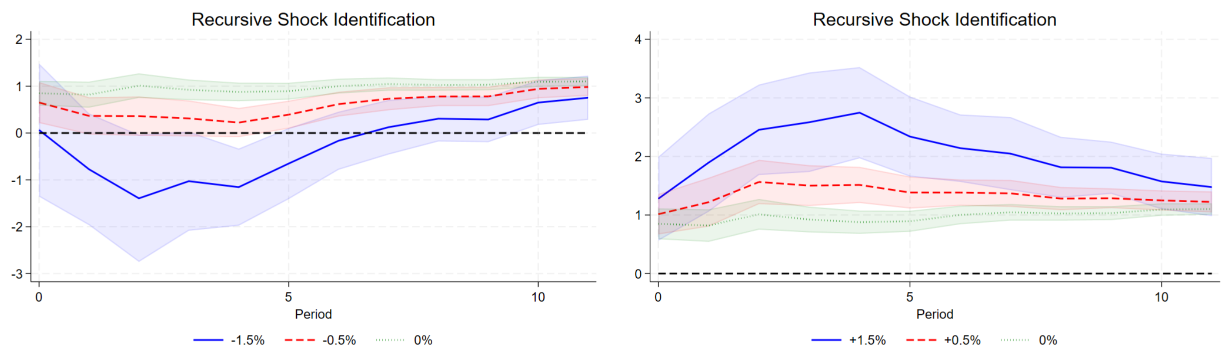


**Figure 1:** Cumulative multiplier for negative shocks on the left panel and for positive shocks on the right panel. Colored areas represent the 95th confidence interval.

### 2.2.1 Comparison with Barnichon et al. (2022) and Ben Zeev et al. (2023)

While we find the size of the fiscal multiplier to be larger for large positive shocks and smaller for large negative shocks, Barnichon et al. (2022) find that negative shocks yield a larger multiplier than positive ones. A few differences in the approach and methods used explain the differences in results between the two papers. First, using military news shocks instead of the BP ones flips the results. Figure 15 in A.2 shows that using military news shocks, we find a result similar to Ben Zeev et al. (2023), where negative shocks yield larger multipliers but the multipliers are not statistically different from each other.

Ramey and Zubairy (2018) advocate for the use of the BP shocks to capture short term effects of fiscal policy, as the military shocks have an average lag of two years between the time of the announcement and when they are actually implemented. For this reason, we prefer the BP shocks, as the model results presented in Section 5 will equally focus on the short run effects of fiscal policy.

Second, the method used may also play an important role. While Barnichon et al. (2022) using the Functional Approximations of Impulse Responses (FAIR) method find, using the BP shocks, the fiscal multiplier to be larger for negative shocks, we find the opposite result using local projections. BDM advocate the use of the FAIR method based on efficiency gains, acknowledging the method induces bias.[9] This induced bias may, in

[9] Ben Zeev et al. (2023) shows that, in fact, the local projections methods provides more precise estimates

part, explain the differences compared to the results we find using local projections.

Third, the average values for both positive and negative BP shocks are relatively small and close to zero. This means that, when simply comparing average positive to average negative shocks, the nonlinearity may not be strong enough to be statistically and economically significant, in line with what Ben Zeev et al. (2023) suggests. Our quadratic specification effectively treats small and large shocks differently, thus allowing us to capture nonlinearities that may only be statistically detectable for the latter.

# 3 Heterogeneous Agents Model

In this section, we develop a standard incomplete markets model that we then calibrate to resemble the U.S. economy and use to study the nonlinear effects of fiscal policy.

## *3.1 Technology*

The production sector is standard, with the representative firm having access to a Cobb-Douglas production function,

$$Y_t(K_t, L_t) = K_t^{\alpha} L_t^{1-\alpha}$$

where $L_t$ is the labor input, measured in efficiency units, and $K_t$ is the capital input. The law of motion for capital is

$$K_{t+1} = (1-\delta)K_t + I_t$$

where $\delta$ is the capital depreciation rate and $I_t$ is the gross investment. Firms choose labor and capital inputs each period in order to maximize profits:

$$\Pi_t = Y_t - w_t L_t - (r_t + \delta)K_t.$$

than the FAIR method.

In a competitive equilibrium, factor prices are paid their marginal products:

$$w_t = \frac{\partial Y_t}{\partial L_t} = (1-\alpha)\left(\frac{K_t}{L_t}\right)^{\alpha}$$
$$r_t = \frac{\partial Y_t}{\partial K_t} - \delta = \alpha\left(\frac{L_t}{K_t}\right)^{1-\alpha} - \delta$$

### 3.2 *Demographics*

The economy is populated by a continuum of infinitely lived households. Households differ with respect to their permanent ability levels assigned at birth, $a$, persistent idiosyncratic productivity shocks, $u$, asset holdings, $k$, and time discount factors that are uniformly distributed and can take three distinct values, $\beta \in \{\beta_1, \beta_2, \beta_3\}$. Agents choose how much to work, $n$, consume, $c$, and save, $k'$, to maximize expected lifetime utility.

### 3.3 *Labor Income*

The hourly wage received by an individual depends on the wage per efficiency unit of labor, $w$, permanent ability $a \sim N(0, \sigma_a^2)$, and an idiosyncratic productivity shock $u$, which follows an AR(1) process:

$$u' = \rho u + \epsilon, \quad \epsilon \sim N(0, \sigma_\epsilon^2).$$

The wage rate per hour worked by an individual $i$ is given by

$$w_i(a, u) = we^{\gamma + a + u}$$

where $\gamma$ is a constant used to normalize the average earnings in the economy to 1.[10]

[10]Normalizing average earnings to 1 is for example helpful when mapping an estimated nonlinear income tax code from the data to the model, like we do in C. We estimate the tax function on income normalized by Average Earnings in the data $y/AE$. Thus a person with average earnings in the data and model will have an income of 1.

## 3.4 *Preferences*

Households' utility in a given period $U(c,n)$ is standard: time-additive, separable, and isoelastic, with $n \in (0,1]$:

$$U(c,n) = \frac{c^{1-\sigma}}{1-\sigma} - \chi\frac{n^{1+\eta}}{1+\eta}$$

Each household maximizes their expected lifetime utility:

$$\max_{\{c_t,n_t,k_t\}_{t=0}^{\infty}} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t U(c,n)$$

## 3.5 *Government*

Government revenues include a distortionary labor tax $\tau_l$. Tax revenues are used to finance public consumption of goods, $G_t$; lump-sum transfers, $g_t$; and interest expenses on public debt, $rB_t$. Denoting tax revenues as $R$, the government budget constraint is defined as:

$$g \int \mathrm{d}\Phi + G + rB = R$$

## 3.6 *Recursive Formulation of the Household Problem*

In a given period, a household is defined by their asset position $k$, time discount factor $\beta$, permanent ability $a$, and persistent idiosyncratic productivity $u$. Given this set of states, the household chooses consumption, $c$; work hours, $n$; and future asset holdings, $k'$, to maximize the present discounted value of expected utility. The problem can be written recursively as:

$$V(k,\beta,a,u) = \max_{c,k',n} \left[ U\left(c,n\right) + \beta \mathbb{E}_{u'}\left[V(k',\beta,a,u')\right]\right]$$

s.t.:

$$c + k' = k\left(1+r\right) + g + nw\left(a,u\right)\left(1-\tau_l\right)$$

$$n \in [0,1], \quad k' \geq -b, \quad c > 0$$

where $b$ is an exogenous borrowing limit.

### 3.7 Stationary Recursive Competitive Equilibrium

Let the measure of households with the corresponding characteristics be given by $\Phi(k, \beta, a, u)$. Then, we can define a stationary recursive competitive equilibrium (SRCE) as follows:

1. Taking the factor prices and the initial conditions as given, the value function $V(k, \beta, a, u,)$ and policy functions $c(k, \beta, a, u)$, $k'(k, \beta, a, u)$, $n(k, \beta, a, u)$ solve the households' optimization problems.

2. Markets clear:
$$K + B = \int k \mathrm{d}\Phi$$
$$L = \int n(k, \beta, a, u) \mathrm{d}\Phi$$
$$\int c \mathrm{d}\Phi + \delta K + G = K^{\alpha} L^{1-\alpha}.$$

3. Factor prices are paid their marginal products:
$$\begin{aligned} w &= (1-\alpha)\left(\frac{K}{L}\right)^{\alpha} \\ r &= \alpha\left(\frac{K}{L}\right)^{\alpha-1} - \delta. \end{aligned}$$

4. The government budget balances:
$$g \int \mathrm{d}\Phi + G + rB = \int \left[nw\left(a, u\right)\left(1 - \tau_l\right)\right] \mathrm{d}\Phi.$$

### 3.8 Fiscal Experiments and Transition

Our baseline fiscal experiments consist of changes in government spending $G$ of different sizes (measured as a percentage of GDP) and under different financing regimes. This is important, as Ricardian equivalence does not hold in our model and therefore the type and timing of the financing of the shock can matter substantially for its effects on output.

1. Permanent debt consolidations and expansions. In the case of a consolidation, $G$ decreases temporarily so as to allow public debt to fall. The economy then transitions to a new SRCE with lower public debt and $G$ returns to its original level. The expansion is defined symmetrically.

2. Temporary deficit-financed reductions and increases in $G$. Initially, the reduction in $G$ leads to a fall in debt. Transfers adjust to pay back the debt and bring the economy back to the initial SRCE according to the following fiscal rule

$$g = g_{ss} + \phi_T \left( \frac{B_{-1}}{B_{ss}} - 1 \right).$$

3. Temporary balanced-budget-financed reductions and increases in $G$. In the case of a reduction, lump-sum transfers increase to clear the government budget constraint and maintain debt at a constant level. Eventually, the economy transitions back to the initial SRCE.

We delegate the formal definition of a transition equilibrium to B.

# 4 Calibration

We calibrate the starting SRCE of our model to the US economy. Some parameters are calibrated directly from empirical counterparts, while others are calibrated using the simulated method of moments (SMM) so that the model matches key features of the US economy. D contains a table that summarizes the values for the parameters that are calibrated outside of the model.

### 4.1 *Preferences*

We set the Frisch elasticity of labor supply to 1, as in Trabandt and Uhlig (2011), a standard value in the literature. The disutility of work and the three values for the discount factor ($\chi$, $\beta_1$, $\beta_2$, $\beta_3$) are among the parameters calibrated to match four data moments: the share of hours worked and the three quartiles of the wealth distribution, respectively.

### 4.2 *Taxes and Government Spending*

Following Hagedorn et al. (2019), we set transfers $g$ to be 7% of GDP and government spending $G$ to be 15% of GDP. The labor tax $\tau_l$ is then set so that total tax revenues clear the government budget.

### 4.3 *Endogenously Calibrated Parameters*

Some parameters that do not have any direct empirical counterparts are calibrated using SMM. These are the discount factors, borrowing limit, disutility from working, and variance of permanent ability. The SMM is set so that it minimizes the following loss function:

$$L(\beta_1, \beta_2, \beta_3, b, \chi, \sigma_a) = ||M_m - M_d|| \tag{4}$$

where $M_m$ and $M_d$ are the moments in the model and in the data, respectively.

We use six data moments to choose six parameters, so the system is exactly identified. The six moments we select in the data are (i) the share of hours worked, (ii-iv) the three quartiles of the wealth distribution, (v) the variance of log wages, and (vi) the capital-to-output ratio. Table 5 presents the calibrated parameters, and Table 6 presents the calibration fit.

| Parameter | Value | Description |
|---|---|---|
| Preferences | | |
| $\beta_1, \beta_2, \beta_3$ | 0.987, 0.988, 0.986 | Discount factors |
| $\chi$ | 11.5 | Disutility of work |
| Technology | | |
| $b$ | 1.70 | Borrowing limit |
| $\sigma_a$ | 0.712 | Variance of ability |

**Table 5:** Endogenously calibrated parameters.

| Data moment | Description | Source | Data value | Model value |
|---|---|---|---|---|
| $K/Y$ | Capital-to-output ratio | PWT | 12.292 | 12.292 |
| $\text{Var}(\ln w)$ | Yearly variance of log wages | LIS | 0.509 | 0.509 |
| $\bar{n}$ | Fraction of hours worked | OECD | 0.248 | 0.248 |
| $Q_{25}, Q_{50}, Q_{75}$ | Wealth quartiles | LWS | -0.014, 0.004, 0.120 | -0.016, 0.002, 0.120 |

**Table 6:** Calibration fit.

# 5 Quantitative Results

We now use the calibrated model as a laboratory to study the effects of government spending shocks of different sizes and under different financing regimes. We start by studying permanent debt consolidations: transitions where the debt level at the final steady state is different (lower or higher) than the debt level at the initial steady state. We then analyze temporary changes in $G$ where the economy returns to the initial steady state. We consider both debt financing and balanced budget financing. In C we show that the results are robust to a more realistic tax structure, including labor tax progressivity, capital and consumption taxes.

## 5.1 *Permanent Debt Changes*

We start by considering permanent fiscal consolidations and expansions, the type of experiment that most closely resembles the policies that we empirically analyze in the first part of Section 2. The idea is that the fiscal authority temporarily changes its spending level so as to attain a new level of public debt, lower in the case of consolidations and higher in the case of expansions. More specifically, the experiment consists of temporary changes in $G$ that last for 30 quarters, with no changes in taxes or transfers. At the end of those 30 periods, debt reaches a new steady-state target level and $G$ returns to its initial level, while lump-sum transfers adjust to clear the government budget constraint given the new level of debt. The economy then takes 70 quarters to reach the new steady state with a new debt-to-GDP ratio and different lump-sum transfers.

Figure 2 plots the fiscal multiplier on impact (one quarter after the shock) depending on the size of the initial $G$ variation. The multiplier is monotonically increasing in the shock: it is larger for larger increases in $G$ and smaller for larger decreases in $G$. In other words, the effects of $G$ on $Y$ are nonlinear: the larger is the $G$ shock, the larger the impact on output.

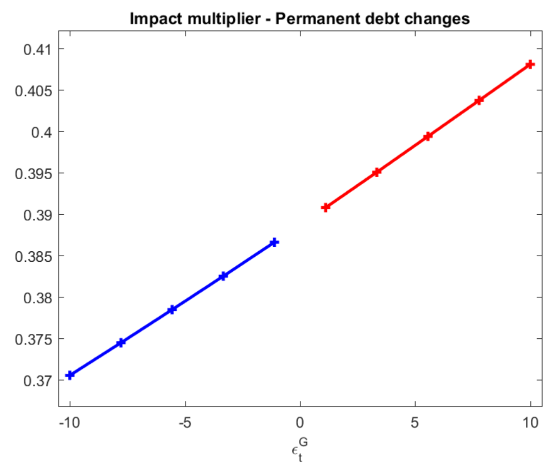


**Figure 2:** Fiscal multiplier on impact for the permanent change in debt experiment as a function of the fiscal shock. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

Figures 3 and 4 shed light on the mechanism at the heart of this paper that generates this pattern. Each presents one of two medchanisms that are key for the result: movements in the wealth distribution, and heterogeneous labor supply responses across the distribution. Figure 3 plots the % of agents with negative wealth one year after the shock, as a function of the size of the shock. The mass of agents with negative wealth is decreasing in the size of the shock: more negative shocks involve larger future reductions in public debt. This generates not only a positive wealth effect, as future lump-sum transfers will be higher, but also a future positive income (human wealth) effect, as debt is crowded out by capital and wages are increasing in the stock of capital. As agents

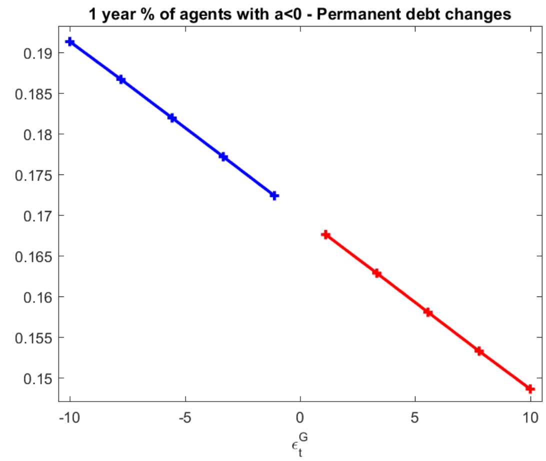


**Figure 3:** Percentage of agents with negative wealth one year after the shock for the permanent change in debt experiment as a function of the fiscal shock. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

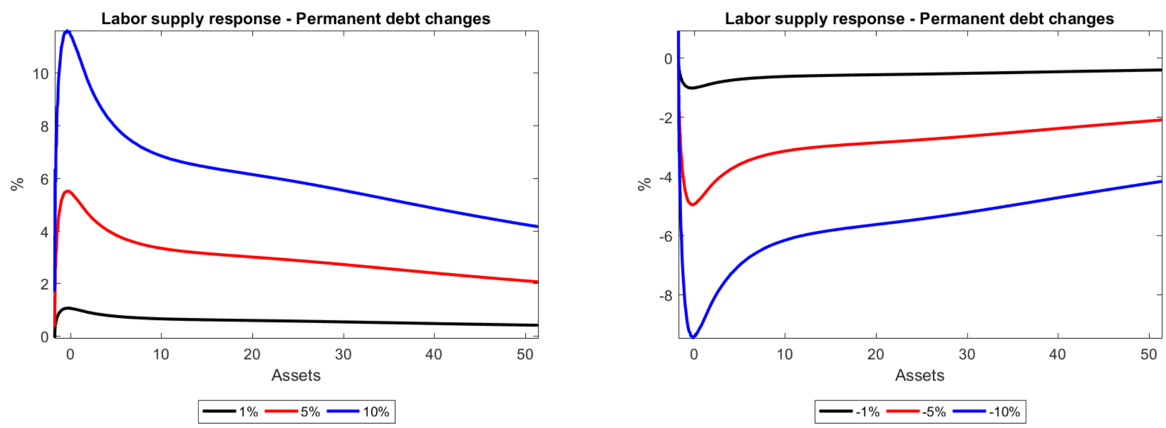


**Figure 4:** (Relative) labor supply response to different changes in $G$ over the asset distribution, for the permanent change in debt experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

internalize these positive wealth and income effects, they find it optimal to borrow more today. Thus more negative consolidations induce more agents to move towards the constraint in the short run.[11] More negative consolidations move agents from the middle of the wealth distribution to the bottom, while more positive consolidations induce the opposite movement of the distribution.

Figure 4 illustrates why these changes in the percentage of constrained agents matter for aggregate dynamics. This figure plots the labor supply response across the wealth

[11]Figure 28 in E illustrates this point by plotting the overall movement of the entire wealth distribution in response to the shocks of different sizes.

distribution for shocks of three different sizes (1%, 5%, and 10% of GDP). Notice that the labor supply of constrained and low-wealth agents is less responsive than that of agents in the middle of the distribution. These wealthier agents react strongly to changes in future income and wealth, while constrained agents respond only to changes in the current state (i.e., current taxes and transfers) and not to changes in future states. For this reason, constrained agents essentially do not react to government spending shocks in the short run, regardless of their size. These wealthier agents perceive larger wealth effects from larger spending shocks, hence reduce or increase their labor supply by more.

The mechanism can then be summarized as follows: negative spending shocks move the wealth distribution to the left. As more agents become net borrowers, the result is a smaller aggregate labor supply response and, consequently, a relatively smaller effect on GDP. The opposite is true for positive spending shocks, which move the wealth distribution to the right, to a region where labor supply is more responsive. In summary, the elasticity of aggregate labor supply to government spending shocks is increasing in the size of the fiscal consolidation shock. The same pattern translates to the fiscal multiplier as well.[12]

A permanent change in government spending that is financed by taxes (or lump-sum transfers) would generate qualitatively similar results. In an incomplete markets environment where the Ricardian Equivalence fails to hold, a permanent increase in $G$ that is financed by increased taxes generates a negative wealth effect, shifting the wealth distribution to the left. Assuming that debt remains constant and thus taxes rise contemporaneously, this generates a negative current income effect to which low wealth agents react most strongly. The combination of the leftwards shift in the distribution with this differential response would cause the multiplier to be increasing in the size of the shock, just as in the experiment described above.

[12] Figures 19-21 in C show that the results are robust to a richer tax structure that includes both capital and consumption taxes, as well as labor tax progressivity.

## 5.2 *Temporary Spending Shocks*

We now consider the case of temporary government spending shocks: sequences of shocks to $G$ that result in the same original SRCE in the long run. This is the standard experiment that is typically the focus of quantitative analyzes of fiscal multipliers. We show that the same basic logic applies to this case. Additionally, we consider two types of financing regimes: (i) deficit financing, where the temporary shock is absorbed by changes in public debt until a certain point in time, after which transfers adjust to ensure that the economy returns to the initial (pre-shock) level of public debt, and (ii) balanced-budget financing, in which transfers adjust to keep public debt constant throughout the transition.

### 5.2.1 Path of the Shocks

We follow most literature on fiscal policy and assume that fiscal spending follows an AR(1) process in logs:

$$\log G_t = (1 - \rho_G) \log G_{SS} + \rho_G \log G_{t-1} + \varepsilon_t^G$$

where $\rho_G$ is assumed to be 0.975 at a quarterly frequency, a standard value in the literature. For the deficit financing experiment, we set $\phi_T$ to 0.2 so that debt is back to the steady state level after 100 periods.

### 5.2.2 Deficit Financing

Panel (a) of Figure 5 plots the multiplier as a function of the size of the shock for the case of deficit financing. While the size of the multipliers is now slightly smaller since the shock is no longer permanent, the results are quantitatively similar and the overall pattern remains unchanged from the permanent debt change case.

Figures 7 and panel (a) of 6 show that the basic mechanism still applies. The mass of agents with negative wealth is decreasing on the size of the shock. As these shocks are deficit financed, they cause a future positive wealth effect to which only unconstrained agents respond. Therefore, the smaller the mass of agents that are constrained the larger the responses of the aggregate labor supply and GDP become. This explains why the multiplier is largest for large positive shocks and smallest for large negative shocks.[13] Figure 29 in E shows the overall movement of the wealth distribution, explaining the

[13] Figures 22-24 C present the results under a richer tax structure.

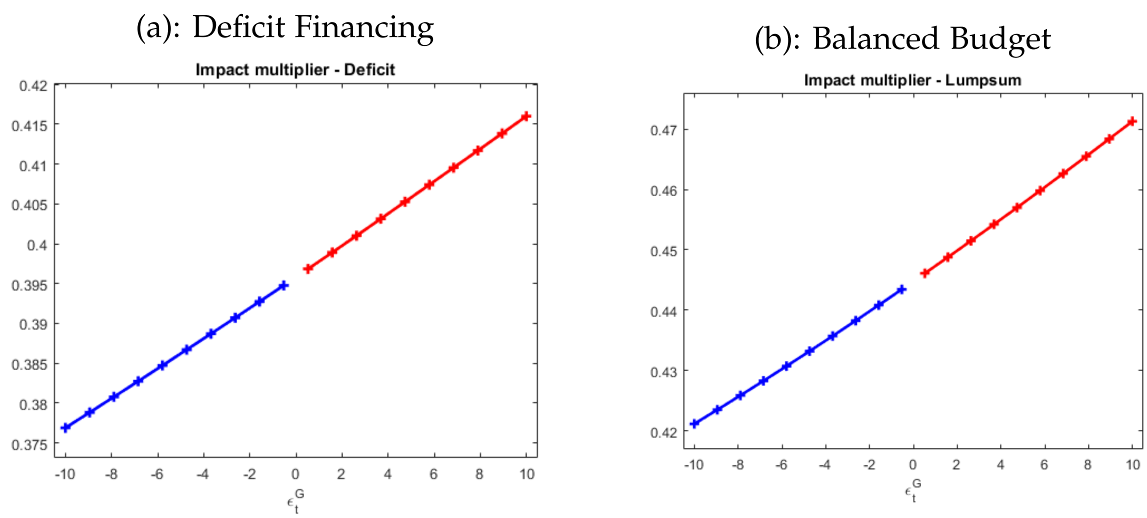


**Figure 5:** Fiscal multiplier on impact as a function of $\varepsilon_t^G$ (the initial impulse), for the deficit financing (a) and balanced budget (b) experiments. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

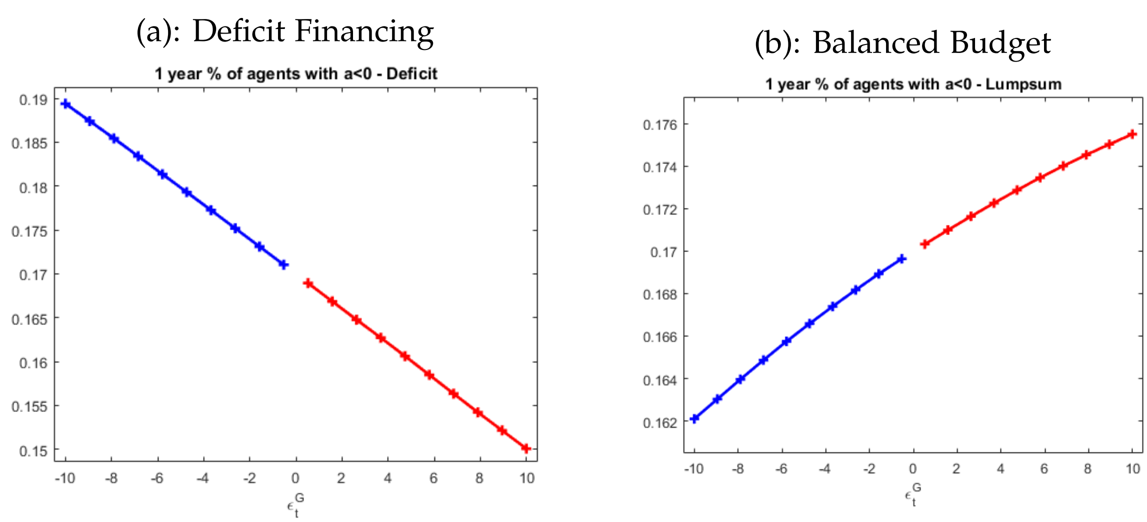


**Figure 6:** Percentage of agents with negative wealth one year after the shock as a function of $\varepsilon_t^G$ (the initial impulse), for the deficit financing (a) and balanced budget (b) experiments. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

mechanism at play.

### 5.2.3 Balanced-Budget

Panel (b) of Figure 5 plots fiscal multipliers for the case where the government runs a balanced budget and thus decreases transfers when $G$ increases so as to keep the level of debt constant. The qualitative results are identical, but the sizes of the multipliers are larger under this financing regime. While the core mechanism still revolves around differences in labor supply responses coupled with shifts in the wealth distribution, these now operate a bit differently. Due to contemporaneous changes in lump-sum transfers, constrained agents now display the largest labor supply responses. An increase in $G$ is associated with a decline in lump-sum transfers, which elicits a much larger labor supply response by constrained and low-wealth agents.

Figure 8 displays the labor supply responses by wealth and the size of the spending shock. These labor supply responses behave in the manner that we would expect, with constrained agents greatly expanding their labor supply in response to a positive shock that decreases transfers. These labor supply responses can be combined with the movements in the distribution presented in panel (b) of Figure 6 to deliver our result: the mass of agents with negative wealth is increasing in the size of the shock. A positive

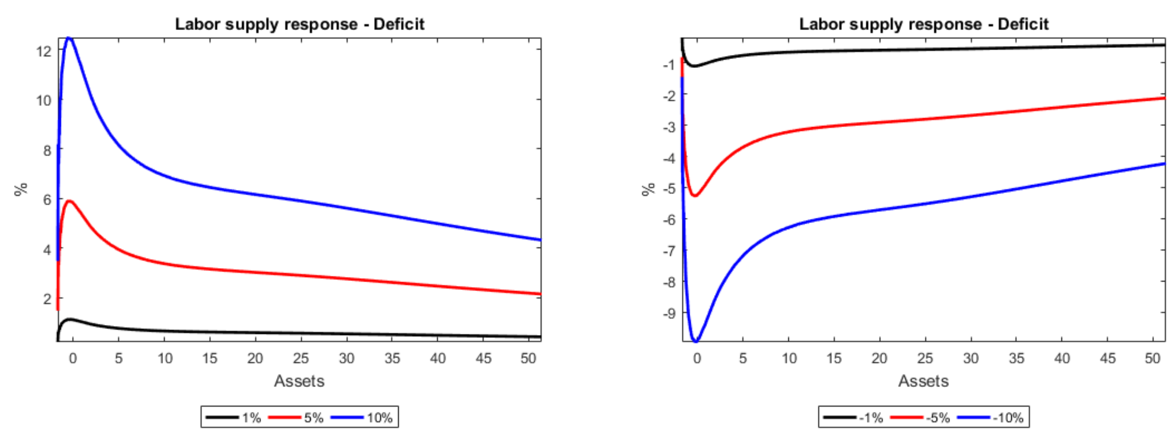


**Figure 7:** (Relative) labor supply response to different changes in $G$ over the asset distribution, for the deficit financing experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

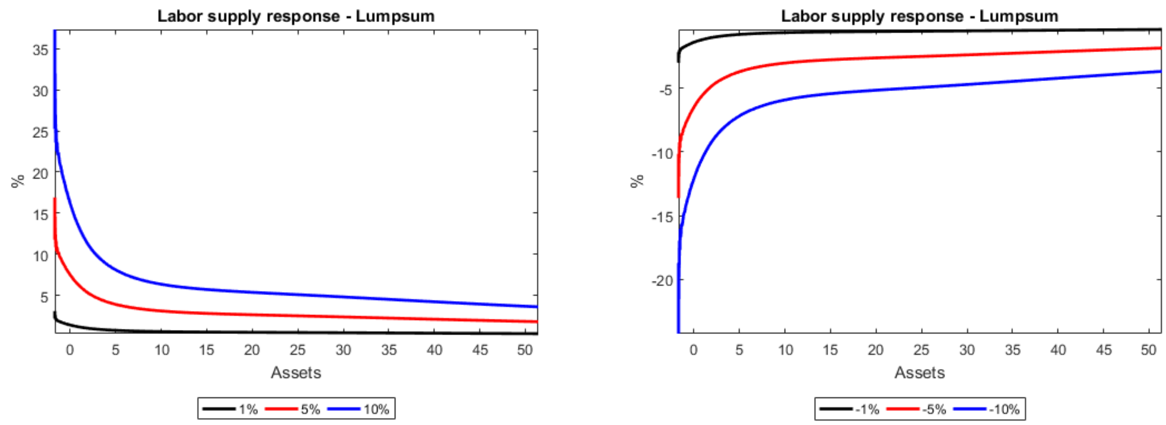


**Figure 8:** (Relative) labor supply response to different changes in $G$ over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive goverbnment spending shocks while the right panel presents the results for negative shocks.

spending shock financed by a contemporary decrease in transfers moves agents towards the constraint, where labor supply is more responsive. Conversely, a negative shock moves agents away from the constraint, where their labor supply is less responsive. The key mechanism again revolves around larger shocks shifting the distribution towards regions where the labor supply response is strongest.[14] Figure 30 in E illustrates exactly this point.[15]

### 5.3 *Validation: Marginal Propensities to Earn*

The mechanism that drives the sensitivity of the multiplier to the fiscal shock crucially hinges on the response of labor supply. This, in turn, is shaped by the individual labor supply responses of agents across the wealth distribution. One question, then, is whether our model generates reasonable individual responses to changes in taxes and transfers. To this end, we define the marginal propensity to earn (MPE) using the definition as in Auclert et al. (2021a): the negative of the response of earned income to a one time, unexpected payment:

[14]Figures 25-27 C present the results under a richer tax structure.
[15]To get better understanding of the forces driving aggregate labor supply (the main driver of the fiscal multiplier in our neoclassical model) during the transition, in F we conduct a partial equilibrium exercise where we isolate the impact of the sequence of prices, the sequence of transfers and the distribution of agents.

$$MPE = -w_i(a,u)\frac{\partial n_t(k,\beta,a,u)}{\partial T_t}$$

where $w_i(a,u)$ corresponds to the effective wage rate per hour worked, and $n_t$ the labor supply policy function. Figure 9 plots the MPE across the asset distribution at the model's stationary equilibrium. As standard theory would predict, MPEs tend to be higher for agents who are closer to the borrowing constraint. The MPE values range from 0.055 to 0, and the aggregate MPE is approximately 0.03, well within the [0,0.04] range for average MPEs that has been reported in the literature, see Auclert et al. (2021a)[16].

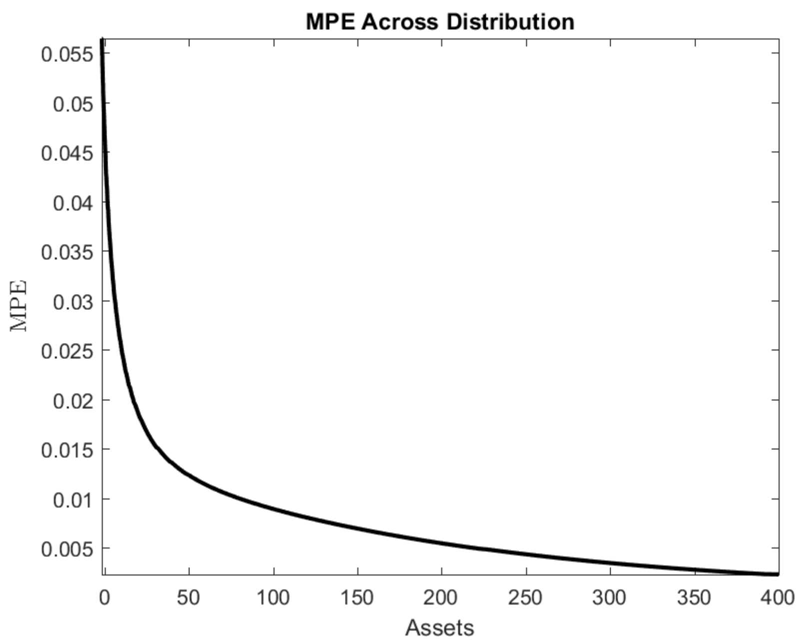


**Figure 9:** Annual marginal propensities to earn across the wealth distribution.

## 5.4 *Multipliers: Model vs. Data*

It is well known that fiscal multipliers in neoclassical models without nominal (and real) rigidities tend to be lower than what empirical estimates typically find. This applies to our model: we find fiscal multipliers that are lower than those we estimate in section 2, as well as a weaker dependence on size of the shock. The next section tries to partly address

[16] Some recent studies based on lottery winners report significantly higher MPEs, see Imbens et al. (2001) and Golosov et al. (2023)

this issue, by introducing nominal rigidities in an incomplete markets heterogeneous agents model. We show that not only the basic mechanism survives in the presence of nominal rigidities, but also that both the level of the multipliers and their sensitivity to the shock are larger.

# 6 Heterogeneous Agents New Keynesian Model

The main source of variation for multipliers that we discussed in the previous sections is a fundamentally neoclassical mechanism that operates via differential changes in the labor supply of agents across the wealth distribution. In principle, it is not clear whether such mechanism should survive the introduction of aggregate demand externalities. In this section, we show that it does in the context of a state-of-the-art heterogeneous agents New Keynesian (HANK) model that closely follows the set up in Auclert et al. (2021b). The details of the HANK model are presented in **??**. We repeat the main fiscal experiments that we conducted in the neoclassical model, and show that they, along with the core mechanism, are robust to the introduction of nominal rigidities.

## *6.1 Balanced Budget*

We assume again that government spending follows an AR(1) in logs, and consider a range of values for $\epsilon_t^G$ that correspond to changes from $-10\%$ to $10\%$ of steady-state government spending on impact. Panel (a) of figure 10 plots the fiscal multipliers for the case where the government runs a balanced budget and adjusts lump-sum transfers so as to keep the level of debt constant. As expected, the HANK model generates larger multipliers than the neoclassical model. Additionally, the HANK model generates a larger sensitivity of multipliers to the shock, with range going from 0.60 to 0.68 in this experiment. Most importantly, the HANK model preserves the same pattern for the fiscal multipliers, increasing in the size of the government spending shock.

To confirm that these results are driven by a similar mechanism, Figure 11 plots labor supply responses as a function of wealth for spending shocks of different sizes. As before, constrained agents at the bottom of the wealth distribution expand their labor supply response by more in response to positive spending shocks, i.e. a decrease in lump-sum transfers. Panel (a) of figure 12 shows that, just as in the neoclassical model, an increase in government spending is associated with more constrained agents. These two facts combined help explain the pattern, as a fiscal contraction reduces the mass of agents that are most responsive to the shock, while a fiscal expansion increases the mass of agents that are most responsive. A natural question is whether our result could be overturned by sufficiently strong aggregate demand externalities: a fiscal expansion leads to a reduction in transfers, which in turn reduces consumption and potentially moderates the increase in output. Our results show that, quantitatively, the neoclassical labor supply effect dominates given our calibration.

### 6.2 *Deficit Financing.*

Panel (b) of figure 10 presents the fiscal multiplier as a function of the shock for the case where the government lets debt clear its budget constraint and sets lump-sum transfers according to the fiscal rule in 10. As expected, deficit financing leads to larger multipliers in the HANK model, as well as to more variability, with multipliers ranging between 0.58

(a): Balanced budget (b): Deficit financing

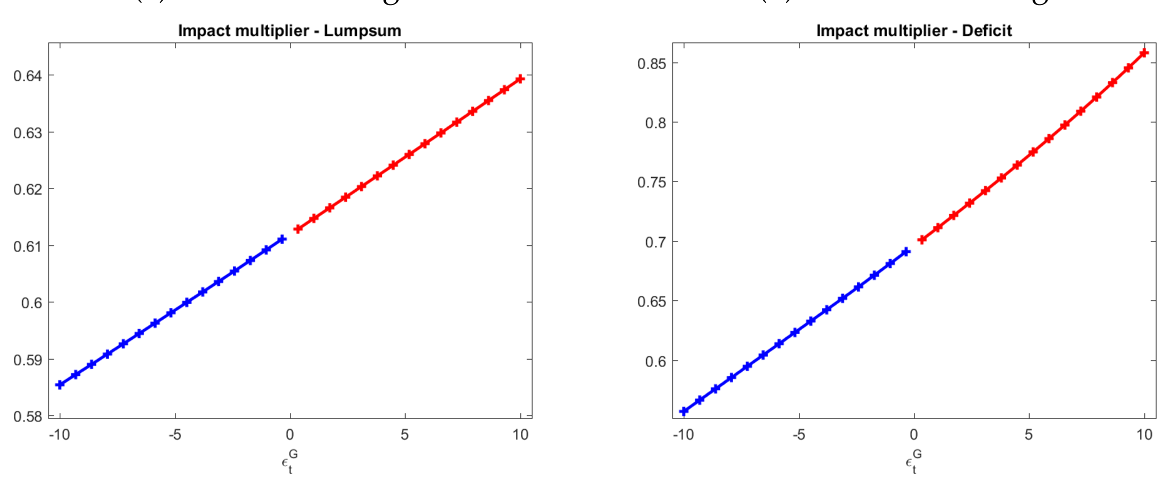


**Figure 10:** Fiscal multipliers on impact (one quarter after the shock) as a function of $\epsilon_t^G$ (the initial impulse)

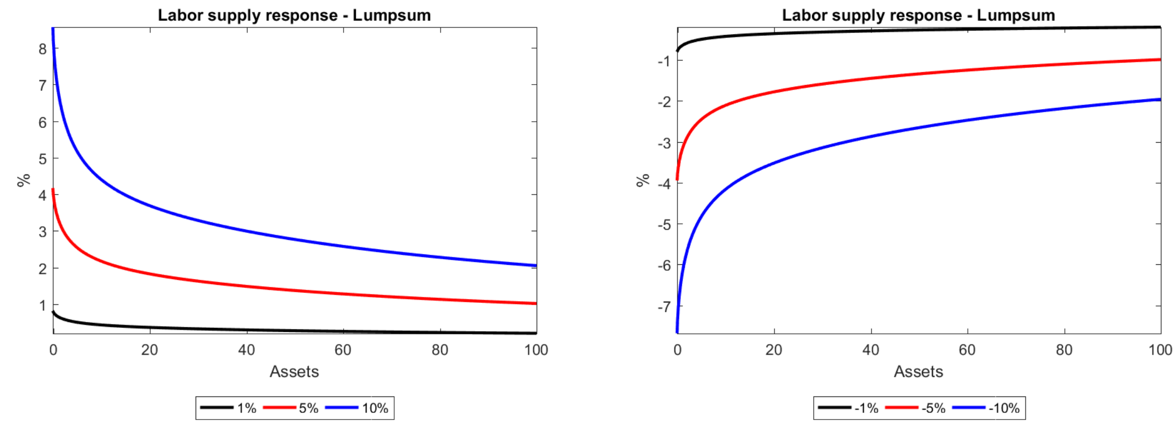


**Figure 11:** : (Relative) labor supply response to different changes in $G$ over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

and 0.84.

Figure 13 plots the labor supply responses by wealth and magnitude of the spending shock. Once again, the HANK model is able to replicate the same pattern as in the neoclassical model, with constrained the labor supply of constrained agents reacting by relatively less, and the mass of agents at the constraint decreasing in the size of the shock as shown in panel (b) of figure 12.

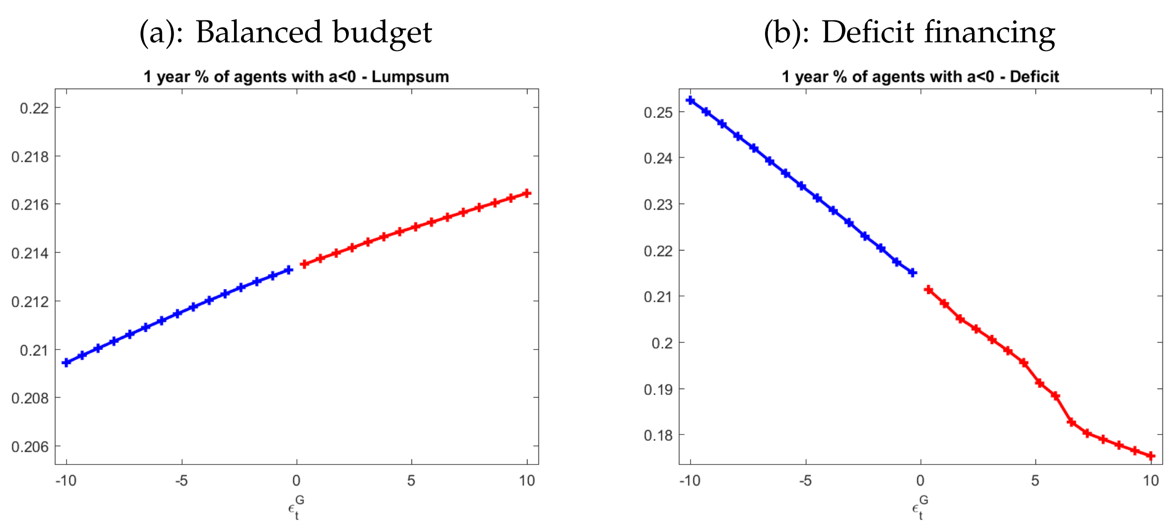


**Figure 12:** Percentage of agents with negative wealth (one year after the shock) as a function of $\epsilon_t^G$ (the initial impulse).

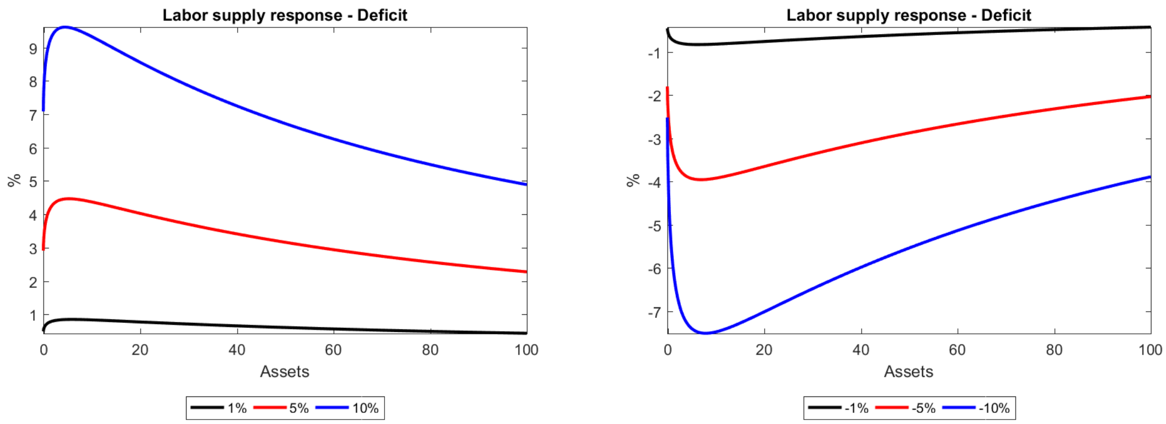


**Figure 13:** : (Relative) labor supply response to different changes in $G$ over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive government spending shocks while the right panel presents the results for negative shocks.

## 6.3 *Model vs. Data*

The results presented above are based on a "standard" calibration for a HANK model, based on Auclert et al. (2021b). Figure 10 shows that while multipliers are larger and more sensitive to the size of the shock, the variation that is generated by the model is still smaller than the one we estimate in the data, i.e. Table 4. To gauge the model's ability to replicate the empirical results, we perform a quantitative exploration in which we change parameters that govern the degree of responsiveness of monetary and fiscal policies. The extent to which monetary policy responds to deviations of inflation from target, and tax rates adjust to close the fiscal deficit have both been shown to matter substantially for the size of the fiscal multiplier in models with nominal rigidities, Leeper et al. (2017). In particular, multipliers tend to be larger when monetary policy is "passive", i.e. the nominal interest rate reacts less to changes in inflation and when fiscal policy is "active", i.e. tax rates react less to changes in deficits, especially when the model includes non-Ricardian agents. While most standard models focus on "active monetary/passive fiscal" regimes, the frequency and length of such policy regime changes are areas of active research in monetary economics.

Figure 14 plots the impact multiplier under the deficit financing regime, which we consider the most empirically plausible case, in a version of the model where the central bank reacts less to changes in inflation ($\phi_\Pi = 0.9$ vs 1.25 in the baseline) and taxes react less to changes in public debt ($\phi_T = 0.035$ vs. 0.2 in the baseline). The relevant comparison with the baseline is relative to panel (b) of Figure 10. Notice first that the range of shocks is the same we focus on in our empirical exercise, $\epsilon_t^G \in [-1.5\%, 1.5\%]$ of GDP. The fiscal multiplier now ranges from about 0.5 to over 1.8, a similar order of magnitude as the empirical range that we estimate in Table 4. In reality, many other factors should influence the size and the range of the fiscal multiplier, but this numerical illustration shows that even our relatively simple model can do a reasonable job of approximating these characteristics. Table 7 presents cumulative multipliers at different horizons and for different shocks, and shows that the model also reproduces the weakening of the sensitivity as the multiplier horizon increases.

To summarize, we show that a HANK model with relatively passive monetary policy and active fiscal policy is able to reproduce three aspects of our empirical results in

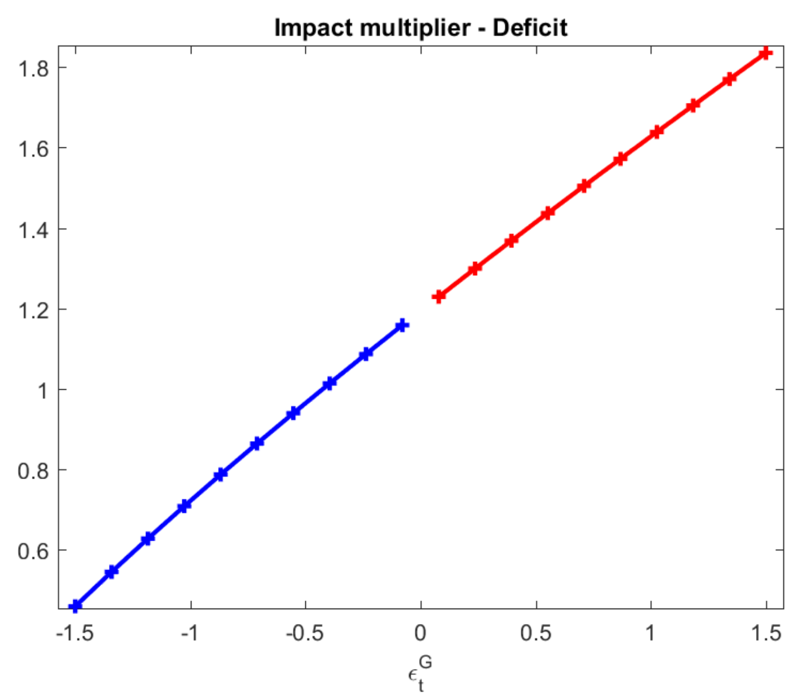


**Figure 14:** : Impact multipliers, deficit financing, less responsive Taylor and tax rules $\phi_\Pi = 0.9, \phi_T = 0.035$.

| Horizon/Shock | -1.5% | -0.5% | +0.5% | +1.5% |
|---|---|---|---|---|
| 0 | 0.459 | 0.964 | 1.414 | 1.835 |
| 1 | 0.479 | 0.976 | 1.411 | 1.808 |
| 2 | 0.499 | 0.989 | 1.409 | 1.784 |
| 3 | 0.518 | 1.000 | 1.407 | 1.764 |
| 4 | 0.537 | 1.012 | 1.407 | 1.748 |
| 8 | 0.607 | 1.054 | 1.410 | 1.703 |
| 12 | 0.667 | 1.091 | 1.419 | 1.681 |

**Table 7:** Cumulative multipliers for fiscal shocks of different sizes (columns) at different horizons (rows), HANK model

Table 4: (i) the level of the fiscal multiplier on impact; (ii) the sensitivity of the fiscal multiplier to the size of the fiscal shock (i.e., the range); and (iii) the dynamic behavior of the sensitivity, which weakens along the horizon for which the cumulative multiplier is computed.

# 7 Micro Evidence for the Mechanism

The mechanism we propose hinges on three key factors: (i) the elasticity of intertemporal substitution is increasing in wealth, (ii) there is a shift in the wealth distribution, and (iii) the financing regime for the fiscal shock. Intuitively, we propose that a positive tax-financed shock shifts the wealth distribution to the left. This, along with the fact that the labor supply response to a current income shock is decreasing in wealth, generates a fiscal multiplier that is increasing in the shock. A positive debt-financed shock, on the other hand, shifts the distribution to the right, which combined with a labor supply response to a future income shock that is increasing in wealth, again leads to a fiscal multiplier that is increasing in the shock. Large positive shocks would have the largest multiplier and large negative shocks the smallest.

A number of papers have documented that the EIS is increasing in wealth, see Vissing-Jørgensen (2002) for example for the relationship between wealth and the EIS of consumption and, most notably in our context, Domeij and Floden (2006) for the relationship between wealth and the EIS of labor. Brinca et al. (2021) show that wealthier agents respond more to fiscal consolidation shocks. We here proceed to test for the dependence of the labor supply responses to fiscal shocks on wealth and whether they at all depend on the implied financing regime for the fiscal shocks. To do so we combine micro data from the PSID (1999-2015), which contains bi-annual data on wealth and hours worked, with the data on government spending shocks from Ramey and Zubairy (2018), which we use in Section 2.2.

We identify fiscal shocks as in Section 2.2 (using quarterly data) and then sum these shocks over a 2-year period, which coincides with the interval between wealth-data collection in the PSID. Given that we are aggregating the shocks over a two year period, to get enough variation we use the sum of both Blanchard and Perotti and defense news fiscal shocks.

Table (8) provides an overview of the dataset constructed. We report the aggregate statistics for the sum of the fiscal shock over a two year span, $\sum_{i=0}^{1} G_{t-i}$, and the variations in debt from t-1 to t as percentage of GDP, $\Delta B_t$, as well as statistics for the microdata on the change in hours worked, $\Delta \ln h_t$, and on net wealth, defined as the net value of all assets. We consider a household to be wealthy if it is in the top quartile of the distribution of net wealth. The median change in hours worked is zero, with the top quartile having increases above 10% and the bottom one decreases above 13%. Our sample includes wide variation in government debt, with a median change of 1% and a standard deviation above 4, which provides a good environment to test how different financing regimes affect the response of hours worked to fiscal shocks. To test this, we estimate

| | p25 | p50 | p75 | sd |
|---|---|---|---|---|
| $\Delta \ln h_t$ | -0.13 | 0.00 | 0.10 | (1.96) |
| $\Delta B_t$ | -0.17 | 1.05 | 2.39 | (4.42) |
| $\sum_{i=0}^{1} G_{t-i}$ | -2.16 | 0.52 | 2.00 | (4.98) |
| Net wealth$_t$ | 2,019 | 36,000 | 152,680 | (512,553) |

**Table 8:** Descriptive statistics for the micro data

| VARIABLES | (1) Total wealth <0 | (2) Total wealth >0 | (3) Total wealth < Wealth Q1 | (4) Total wealth < Wealth Q2 | (5) Total wealth > Wealth Q2 | (6) Total wealth > Wealth Q3 |
|---|---|---|---|---|---|---|
| $\beta_1$ | 1.060** | 0.047 | 0.257** | 0.095* | 0.070* | 0.058 |
| | (0.477) | (0.037) | (0.109) | (0.058) | (0.040) | (0.047) |
| $\beta_2$ | 6.355** | 0.750** | 1.580* | 1.035* | 0.533 | 0.269 |
| | (2.603) | (0.349) | (0.883) | (0.533) | (0.361) | (0.399) |
| $\beta_3$ | -0.315** | -0.037** | -0.080* | -0.052** | -0.027 | -0.014 |
| | (0.129) | (0.017) | (0.043) | (0.026) | (0.017) | (0.019) |
| Observations | 7,075 | 61,980 | 14,911 | 33,230 | 40,821 | 20,688 |
| Number of ID | 2,308 | 11,390 | 4,232 | 8,179 | 7,437 | 3,871 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 9:** *G* shock, labor supply response, total wealth, and financing regime

the following equation:

$$\Delta \ln h_{it} = \beta_1 G_t + \beta_2 \Delta B_t + \beta_3 \Delta B_t \times G_t + \alpha_i + \epsilon_{it}$$

where $\Delta B_t$ is the change in government debt as a percentage of GDP, which we take as a proxy for whether fiscal shocks are deficit or tax financed. Similar to what we do in Section 2.2, we instrument $G_t$ with the sum of the government spending shocks between $t-1$ and $t$, $\sum_{i=0}^{1} G_{t-i}$.

The results for this specification are in Table 9 and are consistent with the predictions from our model. The marginal effect of a fiscal shock is given by $\beta_1 + \beta_3 \times \Delta B_t$. A balanced-budget fiscal shock has a marginal effect equal to $\beta_1$: our model predicts that this effect should be positive and larger for households at the bottom of the wealth distribution. The neoclassical version of our model also predicts that deficit-financed fiscal shocks generate smaller multipliers than balanced-budget ones, an effect that is consistent with $\beta_3 < 0$. Since wealthier households respond relatively more to deficit-financed fiscal shocks, this coefficient should be increasing in the wealth quantile (decreasing in absolute value, since it is negative). As the results in Table 9 show, all these predictions are borne by the data and for different sample splits. G shows that these results are robust to: (i) different splits of the sample by net wealth, (ii) using liquid wealth as op-

| VARIABLES | (1) Total wealth <0 | (2) Total wealth >0 | (3) Total wealth < Wealth Q1 | (4) Total wealth < Wealth Q2 | (5) Total wealth > Wealth Q2 | (6) Total wealth > Wealth Q3 |
|---|---|---|---|---|---|---|
| $\beta_1$ | 0.992*** | 0.493*** | 0.938*** | 0.798*** | 0.363*** | 0.228*** |
| | (0.002) | (0.002) | (0.001) | (0.001) | (0.002) | (0.004) |
| $\beta_2$ | -0.501*** | 0.005*** | -0.416*** | -0.234*** | 0.077*** | 0.128*** |
| | (0.002) | (0.002) | (0.002) | (0.001) | (0.002) | (0.004) |
| Observations | 5,559,876 | 24,440,124 | 7,499,997 | 15,000,000 | 15,000,000 | 7,500,000 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 10:** *G* shock, labor supply response, total wealth, and financing regime with neoclassical model simulated data.

posed to wealth, which is defined as net wealth minus real estate assets, (iii) controlling for wages, and (iv) pooling all households in a single regression, and interacting the fiscal shock and debt terms with household wealth levels. The results for these robustness checks can be found in Tables **??**- **??**.

### *7.1 Model vs. Data*

Lastly, we run a similar regression in the neoclassical model, using simulated data. We simulate both labor supply and wealth sequences for five million agents over both balanced budget and deficit financed transitions. We do it for $G$ shocks of different sizes: 1%, 5% and 10% of GDP, so as to generate enough variation in both $G$ and $B$. We then run the following regression with the model data:

$$\Delta \ln h_{it} = \beta_1 G_t + \beta_2 \Delta B_t + \epsilon_i,$$

where $\Delta \ln h_{it}$ is the log change in hours worked from the steady state level to the period of the shock for individual $i$ and transition period $t$, $G_t$ is government spending in the period of the shock for transition period $t$ and $\Delta B_t$ the change in government debt from steady state to the period of the shock for transition $t$.[17] The marginal effect of a fiscal shock, in this case, is given by $\beta_1 + \beta_2$. The purpose of including an interaction term in the empirical regression is to isolate the additional effect of debt changes from the fiscal

[17] Hours worked are annualized so that the coefficients are comparable to the empirical ones.

shock. As all changes in $B_t$ in the model are caused by the fiscal shock, there is no need to include the interaction term in the regression and $\beta_2$ in the model regression is the equivalent to $\beta_3$ in the empirical regression.

The results are presented in Table 10 and are in line with the empirical results. First, the overall response to balanced budget fiscal shocks, captured by the $\beta_1$ coefficient, is larger for wealth poor agents. For deficit financed shocks, the additional effect of debt changes, captured by the $\beta_2$ coefficient, causes wealth poor agents to reduce their response to the shock by more than wealthier agents, in line with the $\beta_3$ coefficient from the empirical regression.

# 8 Conclusion

In this paper, we contribute to the analysis of the aggregate effects of government spending shocks by empirically documenting that fiscal multipliers are increasing in the size of the shock, contrary to what is commonly assumed in the literature. We show that the standard incomplete markets model can reproduce this fact, generating a multiplier that is nonlinear in the spending shock. Large negative shocks yield smaller multipliers, and large positive shocks yield larger multipliers. This holds both for debt-financed and balanced-budget-financed shocks.

We have shown that the response of labor supply across the wealth distribution, along with the response of this very same distribution, are crucial in generating this pattern of multipliers that are increasing in the shock. The EIS is increasing in wealth, which implies that low-wealth agents respond more to current income shocks and less to future income shocks. A positive tax-financed shock shifts the wealth distribution to the left. This, along with the fact that the labor supply response to a current income shock is decreasing in wealth, generates a fiscal multiplier that is increasing in the shock. A positive debt-financed shock, on the other hand, shifts the wealth distribution to the right, which combined with a labor supply response to a future income shock that is increasing in wealth, leads again to a fiscal multiplier that is increasing in the shock. Using micro-data from the PSID, we validate the relationship between wealth, labor supply responses and fiscal shocks.

Recent events such as the COVID-19 crisis have led to large fiscal programs that will likely require some type of consolidation in the future. We believe our work is important to understand how the effects of these consolidation programs vary with their size.

We see this paper as contributing to understanding how the size of fiscal shocks can have different aggregate implications depending on the distributional features of the economy. We show that introducing nominal rigidities can greatly magnify the aggregate effects of this size and sign-dependence. Extending the model along other dimensions could further amplify these nonlinearities: for example, if wealthier consumers could be borrowing constrained as in Kaplan and Violante (2014). This would allow for larger masses of agents to be shifted to and from the constraint. Furthermore, in this paper we focused essentially on the role of heterogeneous marginal propensities to work in the transmission of fiscal policies. We leave for future research a more detailed investigation on how the joint distribution between marginal propensities to work and consume can affect the sign and size dependence of fiscal policy shocks.

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# A Additional Empirical Evidence

## A.1 IMF Shocks

| Instrument | Variable | h: 0 | 1 | 2 |
|---|---|---|---|---|
| G | Multiplier 0% | 1.011 | 2.009 | 0.613 |
| | Multiplier -0.5% | 0.610 | 1.436 | 0.412 |
| | Multiplier -1.5% | -0.192 | 0.290 | 0.010 |
| g | Multiplier 0% | -0.250 | 0.494 | -0.011 |
| | Multiplier -0.5% | -0.270 | 0.373 | 0.052 |
| | Multiplier -1.5% | -0.310 | 0.131 | 0.134 |
| t | Multiplier 0% | 0.975 | 1.915 | 1.504 |
| | Multiplier -0.5% | 0.689 | 1.538 | 1.114 |
| | Multiplier -1.5% | 0.117 | 0.784 | 0.334 |

**Table 11:** Fiscal multipliers for different unanticipated government consumption, transfers and taxed based consolidation shocks, including controls, at different horizons $h$.

| Variable | h: 0 | 1 | 2 |
|---|---|---|---|
| $\beta_1^u$ | -0.455*** | -1.165*** | -0.474*** |
| | (0.135) | (0.172) | (0.144) |
| $\beta_2^u$ | 0.114*** | 0.189*** | 0.099*** |
| | (0.034) | (0.043) | (0.038) |
| $\beta_1^a$ | -0.377** | -0.018 | -0.327* |
| | (0.167) | (0.208) | (0.193) |
| $\beta_2^a$ | -0.035 | -0.138 | 0.141 |
| | (0.064) | (0.096) | (0.100) |
| Observations | 495 | 480 | 465 |
| Number of countries | 15 | 15 | 15 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 12:** Non-linear effects of fiscal unanticipated and announced consolidation shocks. $\beta_1$ and $\beta_2$ stand for the coefficients associated with the linear and quadratic terms, respectively. $\beta^u$ and $\beta^a$ stand for the coefficients associated with unanticipated and anticipated shocks, respectively.

| | Mean | Median | Std. Dev. | Observations |
|---|---|---|---|---|
| Unanticipated t | 0.290 | 0 | 0.587 | 63 |
| Unanticipated G | 0.222 | 0.0302 | 0.392 | 63 |
| Unanticipated g | 0.310 | 0.0959 | 0.420 | 63 |
| Anticipated t | 0.102 | 0.0432 | 0.391 | 63 |
| Anticipated G | 0.135 | 0.0802 | 0.184 | 63 |
| Anticipated g | 0.215 | 0.0742 | 0.330 | 63 |

**Table 13:** Average anticipated and unanticipated transfer, consumption and tax consolidation components, for a transfer based consolidation in % of GDP.

| | Mean | Median | Std. Dev. | Observations |
|---|---|---|---|---|
| Unanticipated t | 0.230 | 0.00318 | 0.479 | 71 |
| Unanticipated G | 0.455 | 0.276 | 0.523 | 71 |
| Unanticipated g | 0.0843 | 0 | 0.181 | 71 |
| Anticipated t | 0.0556 | 0 | 0.392 | 71 |
| Anticipated G | 0.183 | 0 | 0.339 | 71 |
| Anticipated g | 0.0740 | 0 | 0.142 | 71 |

**Table 14:** Average anticipated and unanticipated transfer, consumption and tax consolidation components, for a consumption based consolidation in % of GDP.

| | Mean | Median | Std. Dev. | Observations |
|---|---|---|---|---|
| Unanticipated t | 0.462 | 0.223 | 0.678 | 77 |
| Unanticipated G | 0.109 | 0 | 0.214 | 77 |
| Unanticipated g | 0.0147 | 0 | 0.132 | 77 |
| Anticipated t | 0.186 | 0 | 0.406 | 77 |
| Anticipated G | 0.0676 | 0 | 0.163 | 77 |
| Anticipated g | 0.0365 | 0 | 0.151 | 77 |

**Table 15:** Average anticipated and unanticipated transfer, consumption and tax consolidation components, for a tax-based consolidation in % of GDP.

| | h | | |
|---|---|---|---|
| Variable | 0 | 1 | 2 |
| $\beta_1^G$ | -0.845*** | -1.894*** | -0.487 |
| | (0.320) | (0.322) | (0.304) |
| $\beta_2^G$ | 0.341*** | 0.544*** | 0.183* |
| | (0.104) | (0.104) | (0.101) |
| $\beta_1^g$ | 0.392* | -0.465 | 0.117 |
| | (0.212) | (0.294) | (0.201) |
| $\beta_2^g$ | -0.004 | 0.117* | -0.060 |
| | (0.057) | (0.069) | (0.061) |
| $\beta_1^t$ | -0.889*** | -1.769*** | -1.483*** |
| | (0.321) | (0.336) | (0.299) |
| $\beta_2^t$ | 0.213 | 0.299** | 0.396*** |
| | (0.131) | (0.126) | (0.118) |
| Observations | 495 | 480 | 465 |
| Number of countries | 15 | 15 | 15 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 16:** Non-linear effects of fiscal unanticipated consumption, transfers and taxed based consolidation shocks, including controls and planned consolidations.

### A.1.1 1991-2014 period including Germany

| | h | | |
|---|---|---|---|
| Variable | 0 | 1 | 2 |
| $\beta_1$ | -0.546*** | -1.024*** | -0.820*** |
| | (0.107) | (0.110) | (0.092) |
| $\beta_2$ | 0.087*** | 0.192*** | 0.181*** |
| | (0.026) | (0.026) | (0.027) |
| Observations | 352 | 336 | 320 |
| Number of countries | 16 | 16 | 16 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 17:** Nonlinear effects of fiscal consolidation shocks at different horizons h.

| | h | | |
|---|---|---|---|
| Variable | 0 | 1 | 2 |
| $\beta_1^G$ | -1.030*** | -1.278*** | -0.682*** |
| | (0.200) | (0.216) | (0.224) |
| $\beta_2^G$ | 0.431*** | 0.409*** | 0.168 |
| | (0.091) | (0.102) | (0.103) |
| $\beta_1^g$ | 0.228* | -0.316** | -0.079 |
| | (0.131) | (0.144) | (0.159) |
| $\beta_2^g$ | 0.003 | 0.116*** | 0.042 |
| | (0.034) | (0.037) | (0.041) |
| $\beta_1^t$ | -0.509*** | -1.350*** | -1.295*** |
| | (0.192) | (0.203) | (0.238) |
| $\beta_2^t$ | 0.088 | 0.116 | 0.281*** |
| | (0.085) | (0.087) | (0.105) |
| Observations | 495 | 480 | 465 |
| Number of countries | 15 | 15 | 15 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 18:** Non-linear effects of fiscal unanticipated consumption, transfers and taxed based consolidation shocks, including controls.

## A.2 US Historical data

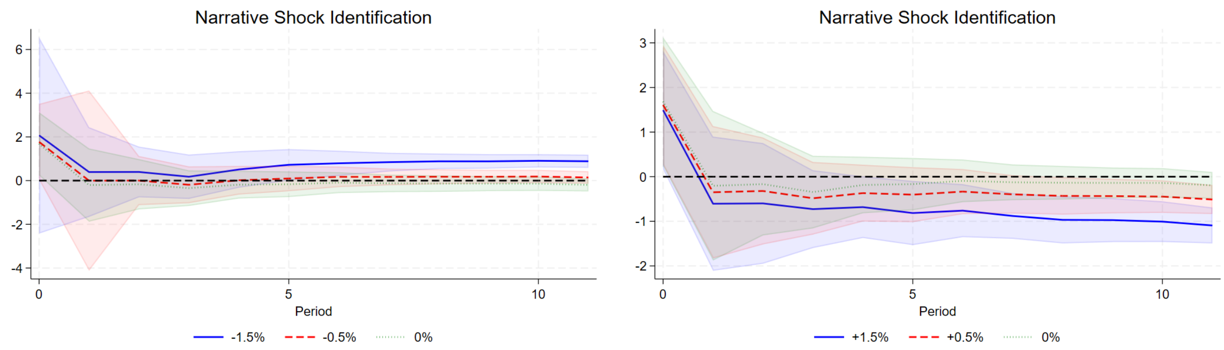


**Figure 15:** Cumulative multiplier for negative shocks on the left panel and for positive shocks on the right panel. Color areas represent the 95th confidence interval.

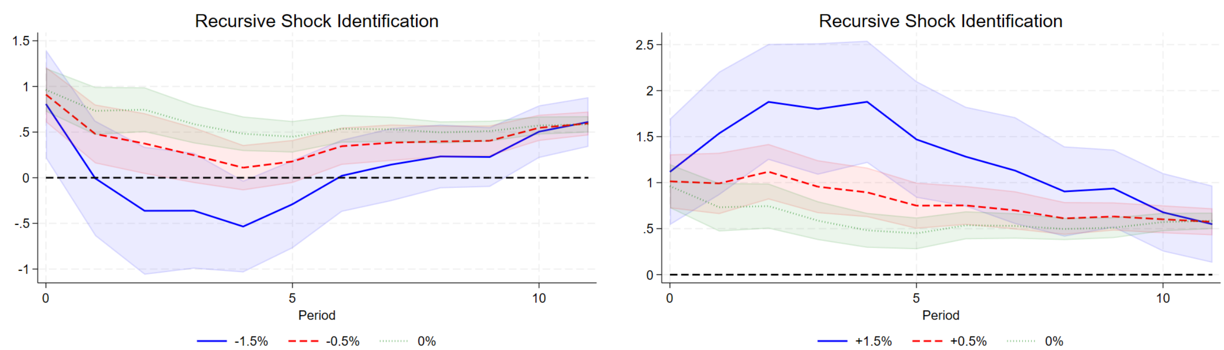


**Figure 16:** Cumulative multiplier for negative shocks on the left panel and for positive shocks on the right panel, controling for taxes. Color areas represent the 95th confidence interval.

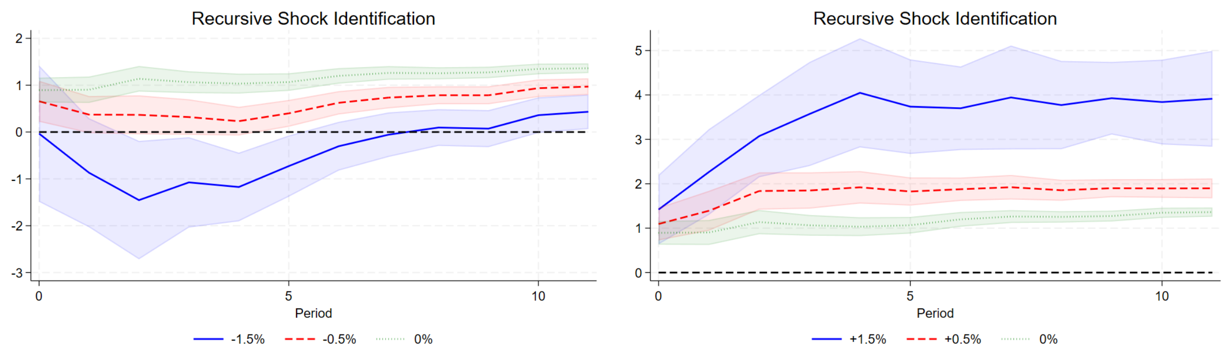


**Figure 17:** Cumulative multiplier for negative shocks on the left panel and for positive shocks on the right panel, controling for both linear and quadratic time trends. Color areas represent the 95th confidence interval.

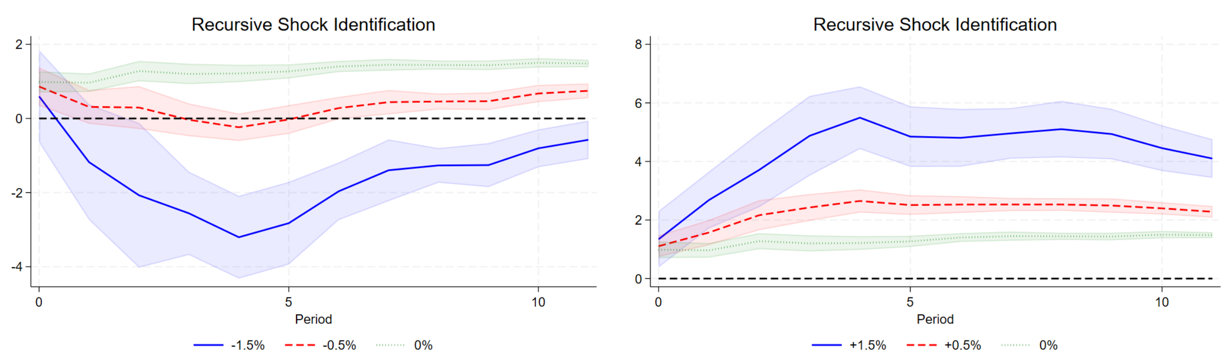


**Figure 18:** Cumulative multiplier for negative shocks on the left panel and for positive shocks on the right panel, with 8 lags. Color areas represent the 95th confidence interval.

# B Definition of a Transition Equilibrium During the Fiscal Experiments

We define the recursive competitive transition equilibrium as follows. For a given level of initial capital stock, initial distribution of households, and initial debt, respectively, $K_0$, $\Phi_0$, and $B_0$, a competitive equilibrium is a sequence of individual functions for the household, $\{V_t, c_t, k_t', n_t\}_{t=1}^{t=\infty}$; production plans for the firm, $\{K_t, L_t\}_{t=1}^{t=\infty}$; factor prices, $\{r_t, w_t\}_{t=1}^{t=\infty}$; government transfers, $\{g_t, G_t\}_{t=1}^{t=\infty}$; government debt, $\{B_t\}_{t=1}^{t=\infty}$; and measures $\{\Phi_t\}_{t=1}^{t=\infty}$ such that the following hold for all $t$:

1. For given factor prices and initial conditions, the value functions $V_t(k, \beta, a, u)$ and the policy functions, $c_t(k, \beta, a, u)$, $k_t'(k, \beta, a, u)$, and $n_t(k, \beta, a, u)$ solve the consumers' optimization problem.

2. Markets clear:

$$K_{t+1} + B_t = \int k_t d\Phi_t$$

$$L_t = \int (n_t(k_t, \beta, a, u))\, d\Phi_t$$

$$\int c_t d\Phi_t + K_{t+1} + G_t = (1-\delta)K_t + K^\alpha L^{1-\alpha}.$$

3. The factor prices are paid their marginal productivity:

$$\begin{aligned} w_t &= (1-\alpha)\left(\frac{K_t}{L_t}\right)^\alpha \\ r_t &= \alpha\left(\frac{K_t}{L_t}\right)^{\alpha-1} - \delta \end{aligned}$$

4. The government budget balances:

$$g_t \int \mathrm{d}\Phi_t + G_t + rB_t = \int \left[\tau_k r_t k_t + \tau_c c_t + n_t w_t\,(a,u)\,(1 - \tau_l\,(n_t w_t\,(a,u)))\right] \mathrm{d}\Phi_t.$$

5. The distribution follows an aggregate law of motion:

$$\Phi_{t+1} = \Upsilon_t(\Phi_t)$$

# C Richer Tax Structure

***Government***

Government revenues include flat-rate taxes on consumption, $\tau_c$, and capital income, $\tau_k$. To model the nonlinear labor income tax, we use the functional form proposed in Benabou (2002) and recently used in Heathcote et al. (2017) and Holter et al. (2019):

$$\tau(y) = 1 - \theta_0 y^{-\theta_1} \tag{5}$$

where $\theta_0$ and $\theta_1$ define the level and progressivity of the tax schedule, respectively; $y$ is the pre-tax labor income; and $y_a = [1 - \tau(y)]y$ is the after-tax labor income.

Tax revenues from consumption, capital, and labor income are used to finance public consumption of goods, $G_t$; interest expenses on public debt, $rB_t$; and lump-sum transfers to households, $g_t$. Denoting tax revenues as $R$ and the measure of households by $\Phi(k, \beta, a, u)$, the government budget constraint is defined as:

$$\int g d\Phi + G + rB = R \tag{6}$$

***Recursive Formulation of the Household Problem***

In a given period, a household is defined by its asset position $k$, time discount factor $\beta$, permanent ability $a$, and persistent idiosyncratic productivity $u$. Given this set of states, household chooses consumption, $c$; work hours, $n$; and future asset holdings, $k'$, to maximize the present discounted value of expected utility. The problem can be written recursively as

$$V(k,\beta,a,u) = \max_{c,k',n}\left[U\left(c,n\right) + \beta\mathbb{E}_{u'}\left[V(k',\beta,a,u')\right]\right]$$

$$\text{s.t.:}$$

$$c(1+\tau_c) + k' = k\left(1 + r(1-\tau_k)\right) + g + nw\left(a,u\right)\left(1 - \tau_l\left(nw\left(a,u\right)\right)\right)$$

$$n \in [0,1], \quad k' \geq -b, \quad c > 0 \tag{7}$$

where $b$ is an exogenous borrowing limit.

***Stationary Recursive Competitive Equilibrium***

Let the measure of households with the corresponding characteristics be given by $\Phi(k,\beta,a,u)$. Then, we can define a stationary recursive competitive equilibrium (SRCE) as follows:

1. Taking the factor prices and the initial conditions as given, the value function $V(k,\beta,a,u,)$ and policy functions $c(k,\beta,a,u)$, $k'(k,\beta,a,u)$, $n(k,\beta,a,u)$ solve the households' optimization problems.

2. Markets clear:

$$K + B = \int k\mathrm{d}\Phi$$

$$L = \int n(k,\beta,a,u)\mathrm{d}\Phi$$

$$\int c\mathrm{d}\Phi + \delta K + G = K^{\alpha}L^{1-\alpha}.$$

3. Factor prices are paid their marginal productivity:

$$\begin{aligned} w &= (1-\alpha)\left(\frac{K}{L}\right)^{\alpha} \\ r &= \alpha\left(\frac{K}{L}\right)^{\alpha-1} - \delta. \end{aligned}$$

4. The government budget balances:

$$g\int \mathrm{d}\Phi + G + rB = \int \left[\tau_k rk + \tau_c c + nw\left(a,u\right)\left(1-\tau_l\left(nw\left(a,u\right)\right)\right)\right]\mathrm{d}\Phi.$$

***Calibration***

***Taxes and Government Spending***

We use the labor income tax function of Benabou (2002) to capture the progressivity of both the tax schedule and direct government transfers. We use the estimate of Holter et al. (2019), who estimate the parameter $\theta_1$ for the US.[18] Consumption and capital tax rates are set to 5% and 36%, respectively, as in Trabandt and Uhlig (2011). Finally, following Hagedorn et al. (2019), we set transfers, $g$, to be 7% of GDP and government spending, $G$, to be 15% of GDP. $\theta_0$ is then set so that total tax revenues clear the government budget.

***Parameters Calibrated Endogenously***

Some parameters that do not have any direct empirical counterparts are calibrated using the SMM. These are the discount factors, borrowing limit, disutility from working, and variance of permanent ability. The SMM is set so that it minimizes the following loss function:

$$L(\beta_1, \beta_2, \beta_3, b, \chi, \sigma_a) = ||M_m - M_d|| \tag{8}$$

where $M_m$ and $M_d$ are the moments in the model and in the data, respectively.

We use six data moments to choose six parameters, so the system is exactly identified. The six moments we select in the data are (i) the share of hours worked, (ii-iv) the three quartiles of the wealth distribution, (v) the variance of log wages, and (vi) the capital-to-output ratio. Table 20 presents the calibrated parameters, and Table 19 presents the calibration fit.

[18]They use OECD data on labor income taxes to estimate the function for different family types. They then weight the value of the parameter by the weight of each family type in the overall population to get an aggregate measures of tax progressivity.

| Data moment | Description | Source | Data value | Model value |
| --- | --- | --- | --- | --- |
| $K/Y$ | Capital-to-output ratio | PWT | 12.292 | 12.292 |
| $\text{Var}(\ln w)$ | Yearly variance of log wages | LIS | 0.509 | 0.509 |
| $\bar{n}$ | Fraction of hours worked | OECD | 0.248 | 0.248 |
| $Q_{25}, Q_{50}, Q_{75}$ | Wealth quartiles | LWS | -0.014, 0.004, 0.120 | -0.018, 0.003, 0.121 |

**Table 19:** Calibration Fit

| Parameter | Value | Description |
| --- | --- | --- |
| Preferences | | |
| $\beta_1, \beta_2, \beta_3$ | 0.991, 0.993, 0.992 | Discount factors |
| $\chi$ | 11.1 | Disutility of work |
| Technology | | |
| $b$ | 1.99 | Borrowing limit |
| $\sigma_a$ | 0.712 | Variance of ability |

**Table 20:** Parameters Calibrated Endogenously

*Permanent Debt Consolidations*

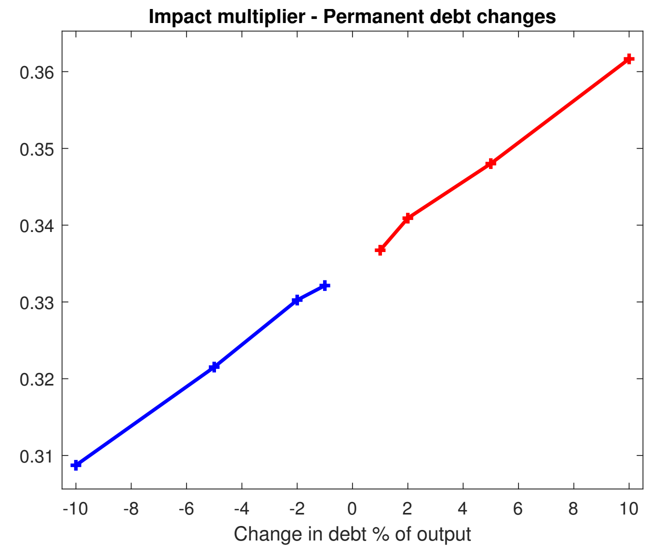


**Figure 19:** Fiscal multiplier on impact (one quarter after the shock) for the permanent change in debt experiment as a function of the size of the variation in $G$ (as a % of GDP). The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

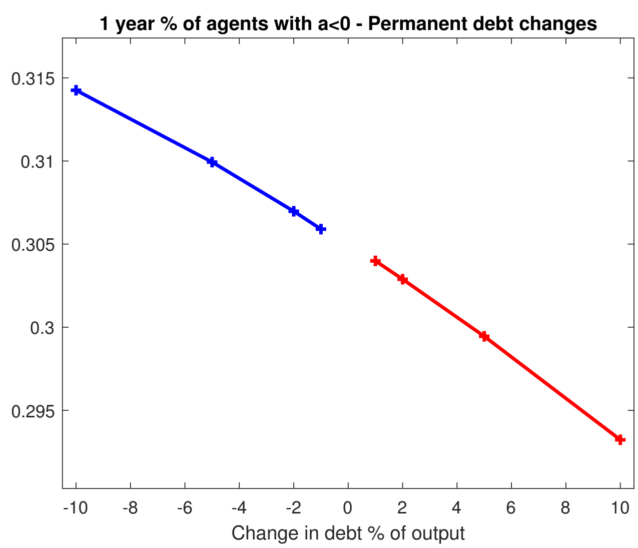


**Figure 20:** Percentage of agents with negative wealth (one year after the shock) for the permanent change in debt experiment as a function of the size of the variation in $G$ (as a % of GDP). The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

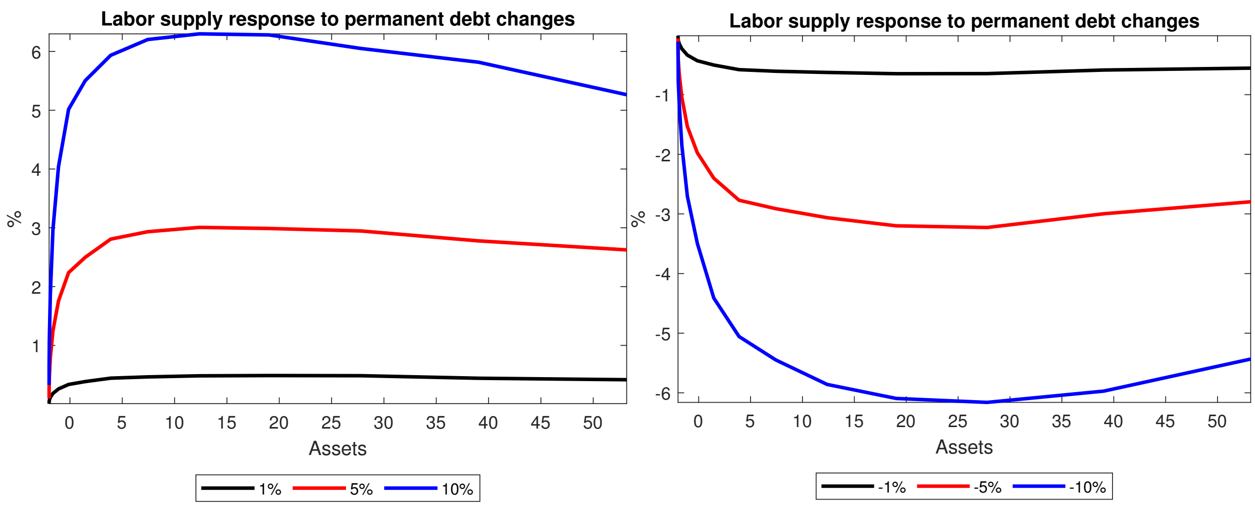


**Figure 21:** (Relative) labor supply response to different changes in $G$ over the asset distribution, for the permanent change in debt experiment. Left panel plots the results for positive fiscal shocks while the right panel presents the results for negative shocks.

*Deficit financing*

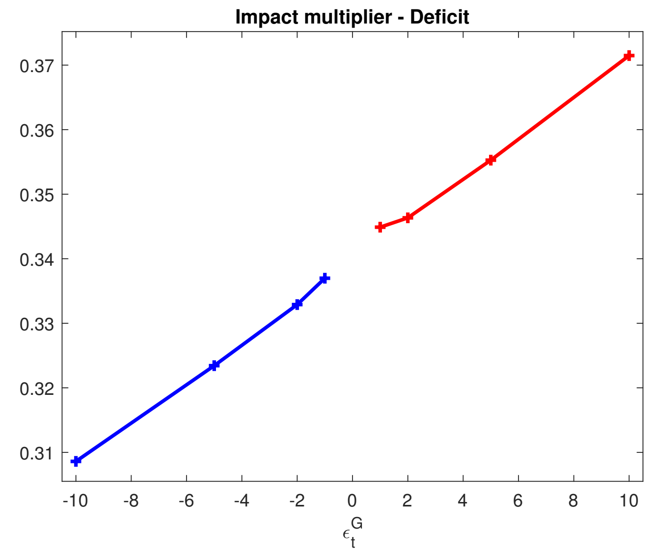


**Figure 22:** This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of $\varepsilon_t^G$ (the initial impulse), for the deficit financing experiment. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

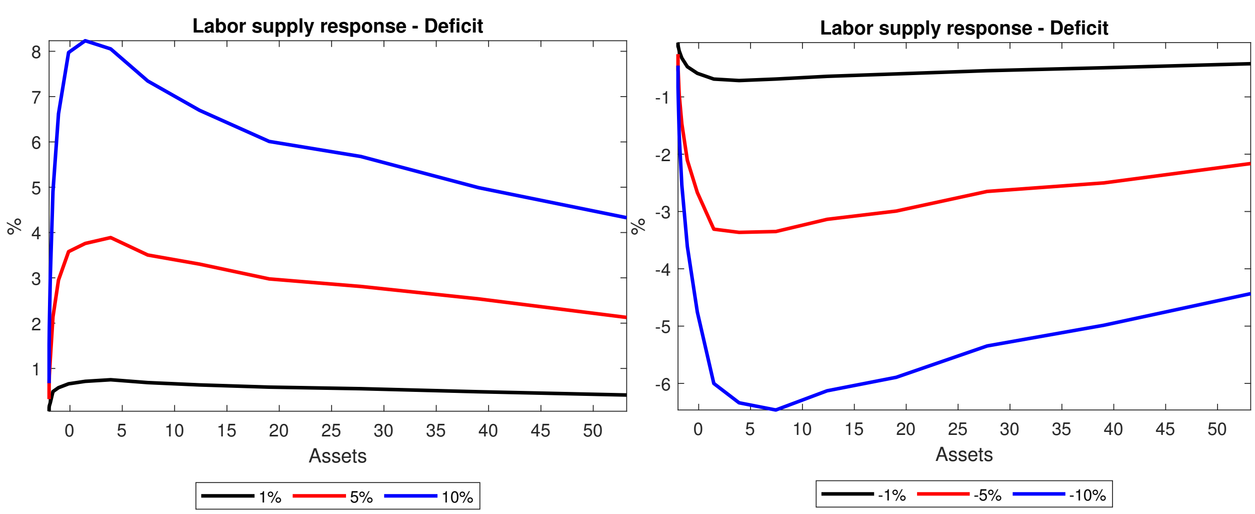


**Figure 23:** (Relative) labor supply response to different changes in $G$ over the asset distribution, for the deficit financing experiment. Left panel plots the results for positive fiscal shocks while the right panel presents the results for negative shocks.

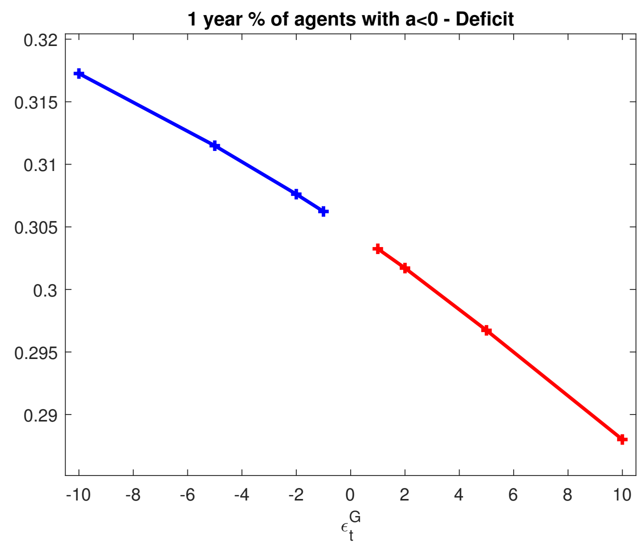


**Figure 24:** This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of $\varepsilon_t^G$ (the initial impulse), for the deficit financing experiment. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

### *Balanced budget*

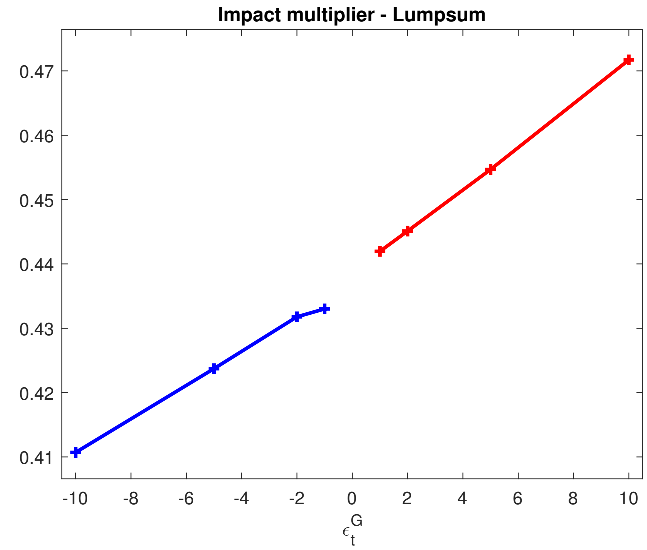


**Figure 25:** This figure plots the fiscal multiplier on impact (one quarter after the shock) as a function of $\varepsilon_t^G$ (the initial impulse), for the balanced budget experiment. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

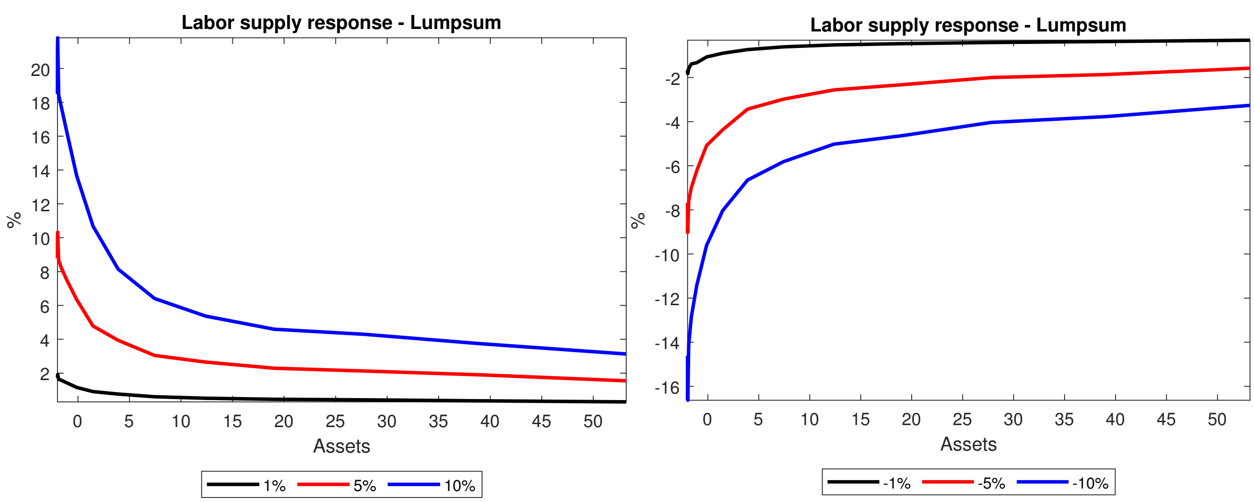


**Figure 26:** (Relative) labor supply response to different changes in $G$ over the asset distribution, for the balanced budget experiment. Left panel plots the results for positive fiscal shocks while the right panel presents the results for negative shocks.

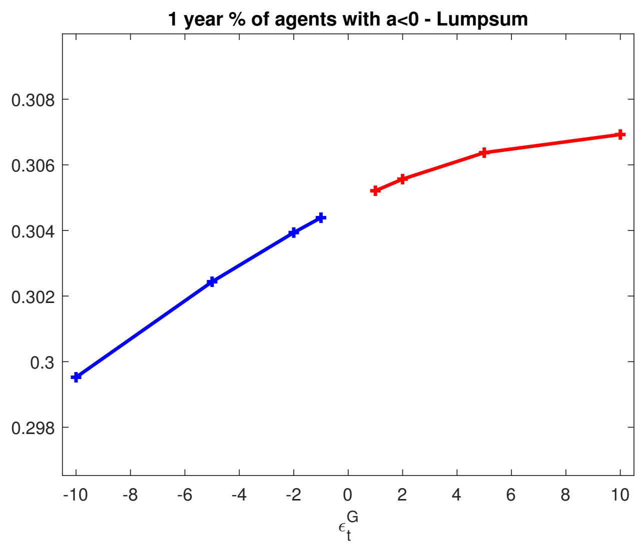


**Figure 27:** This figure plots the percentage of agents with negative wealth (one year after the shock) as a function of $\varepsilon_t^G$ (the initial impulse), for the balanced budget experiment. The blue line corresponds to $G$ contractions, while the red line represents $G$ expansions.

# D Parameters Calibrated Outside of the Model

| Parameter | Value | Description | Source |
|---|---|---|---|
| Preferences | | | |
| $\eta$ | 1 | Inverse Frisch elasticity | Trabandt and Uhlig (2011) |
| $\sigma$ | 1.2 | Risk aversion parameter | Consistent w. literature |
| Technology | | | |
| $\alpha$ | 0.33 | Capital share of output | Consistent w. literature |
| $\delta$ | 0.015 | Capital depreciation rate | Consistent w. literature |
| $\rho$ | 0.761 | $u' = \rho u + \epsilon, \quad \epsilon \sim N(0, \sigma_\epsilon^2)$ | PSID 1968-1997 |
| $\sigma_\epsilon$ | 0.211 | Variance of risk | PSID 1968-1997 |
| Taxes | | | |
| $\theta_0$ | 0.788 | Income tax level | Holter et al. (2019) |
| $\theta_1$ | 0.137 | Income tax progressivity | Holter et al. (2019) |
| $\tau_c$ | 0.047 | Consumption tax | Trabandt and Uhlig (2011) |
| $\tau_k$ | 0.364 | Capital tax | Trabandt and Uhlig (2011) |
| Macro ratios | | | |
| B/Y | 1.714 | Debt-to-GDP ratio | U.S. Data |
| G/Y | 0.15 | Government spending-to-GDP ratio | Budget balance |
| g/Y | 0.07 | Transfers-to-GDP ratio | Hagedorn et al. (2019) |

# E Distribution

## Permanent Shock: Permanent changes in debt

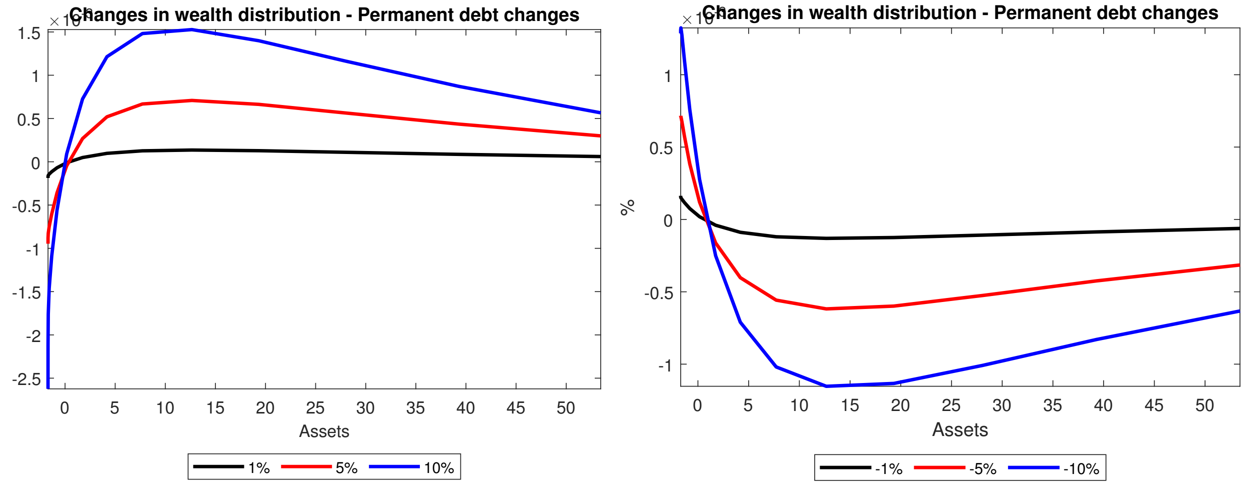


**Figure 28:** Changes in the distribution in response to a permanent change in G.

## Temporary Shock: Deficit Financing

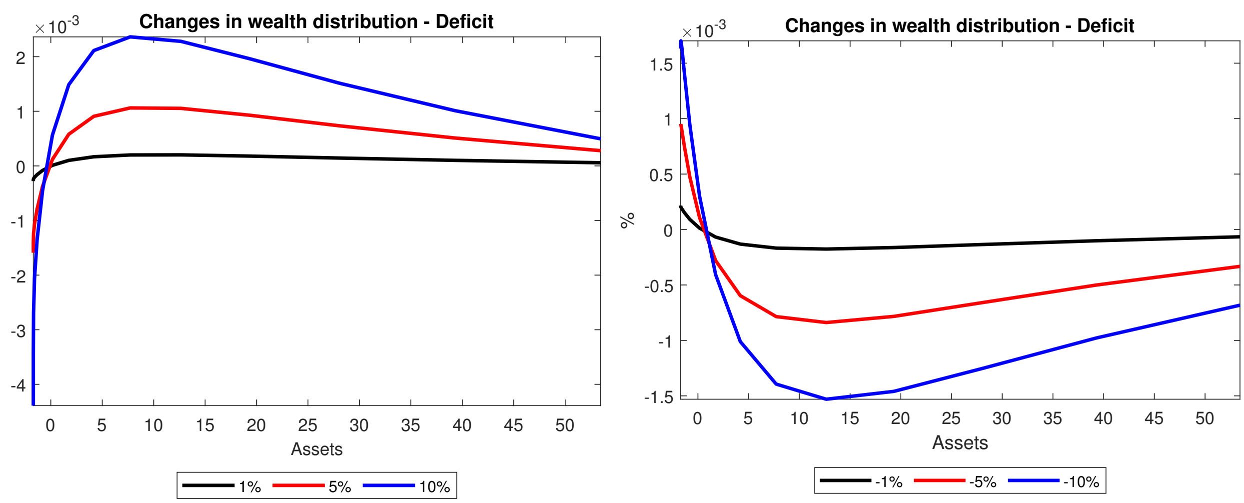


**Figure 29:** Changes in the distribution in response to a permanent change in G.

## Temporary Shock: Balanced Budget

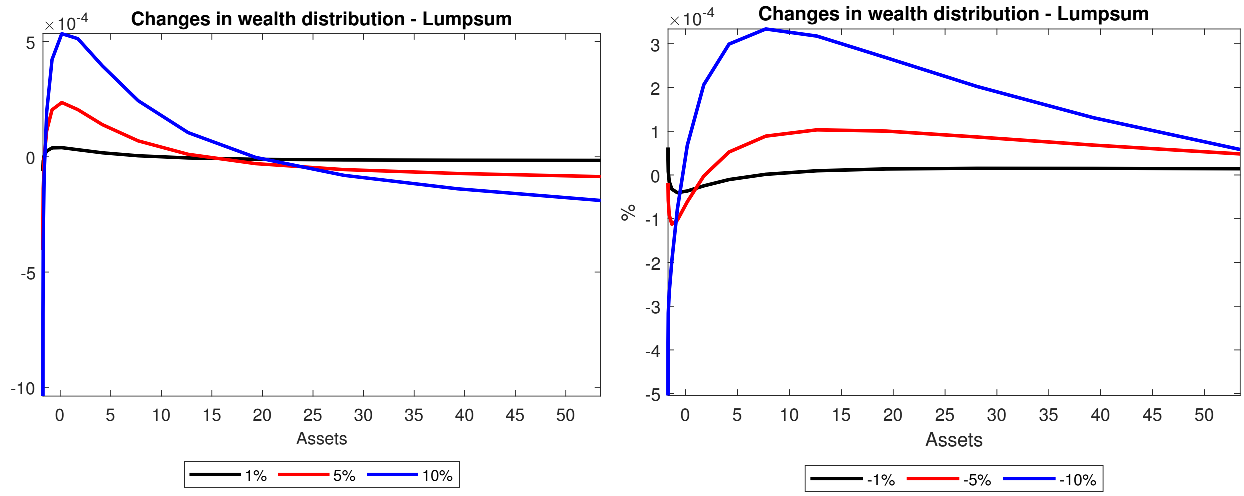


**Figure 30:** Changes in the distribution in response to a permanent change in G.

# F The Impact of Prices, Transfers and the Distribution of Agents on Aggregate Labor Supply

One way to show that both general equilibrium effects (changes in prices) and changes in the distribution are important drivers of aggregate labor supply is to perform a simple partial equilibrium decomposition of the aggregate labor supply response. In particular, we decompose it into three types of partial equilibrium responses by muting one transmission channel at a time: (i) a "price effect", which represents the path of aggregate labor supply when prices (the wage and interest rate) are kept constant at their stationary equilibrium values, and allowing only transfers and the distribution to change; (ii) a "transfer effect" that computes the aggregate labor supply response under the assumption that fiscal transfers do not change, and only prices and the distribution do; and (iii) a "distribution effect", in which the wealth distribution is kept constant, i.e. we aggregate labor supply using the steady state distribution of agents, and only transfers and prices are allowed to change. For each scenario, we compute a counterfactual partial-equilibrium aggregate labor supply by using the relevant distribution of agents and the individual labor supply policies evaluated at the relevant sequences for prices and fiscal transfers.

Figures 31 and 32 plot the results for the balanced budget and deficit financed experiments, respectively. The left panel corresponds to a smaller 1% shock to government spending, while the right panel plots the response of aggregate labor supply to a larger 10% shock. The figure highlights the important role played by general equilibrium effects in the form of prices, as the price effect seems to be the largest of the three: expectations regarding the future path of wages and interest rates are important for savings decisions today, which affect the relative elasticity of labor supply for different agents. For the deficit financed increase in government spending the distribution plays a moderating effect, as the aggregate responses of labor supply would be larger in the absence of changes in the distribution of wealth. The opposite is true in the balanced budget case. We get these effects because labor supply is decreasing in wealth, which increases in the deficit financed experiments and decreases in the balanced budget experiments. This partial equilibrium decomposition is, however, not capturing the behavioral effect of the changes in the wealth distribution, i.e. that higher future wealth makes the agents more forward looking, increasing the response of the policy functions for labor supply (in the deficit financed case). Here we are rather taking the policy functions as given and aggregating them using the steady state distribution of agents.

(a): 1% Shock, Deficit

(b): 10% Shock, Deficit

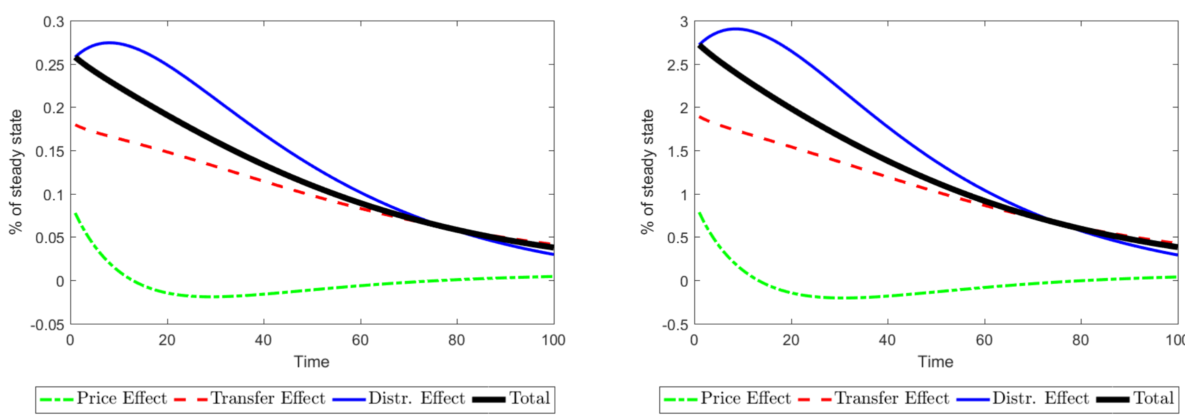


**Figure 31:** Decomposition of aggregate labor supply response to 1% and 10% government spending shocks, deficit financing.

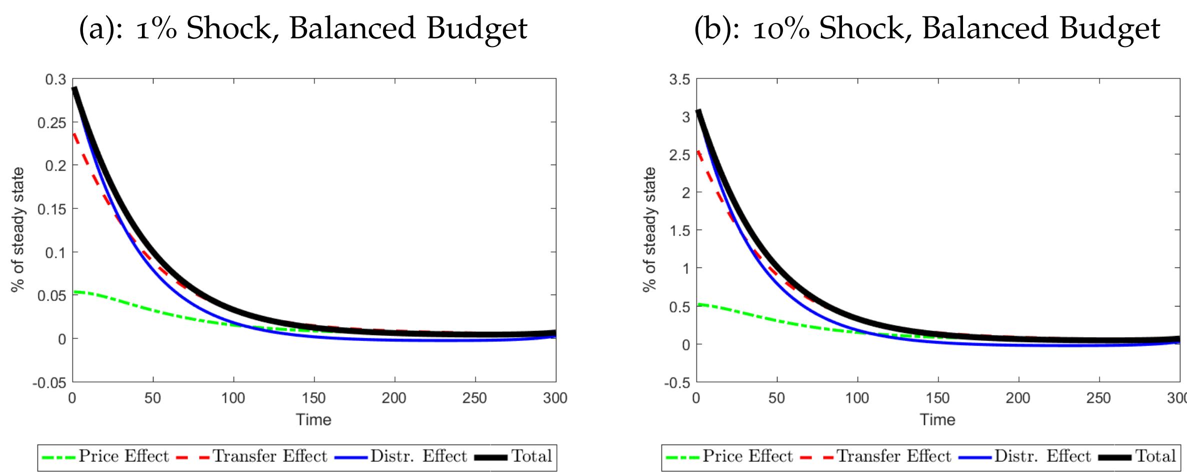


**Figure 32:** Decomposition of aggregate labor supply response to 1% and 10% government spending shocks, balanced budget experiment.

# G Robustness: Micro Evidence of the Mechanism

## *G.1 Setup*

The setup follows closely that of the neoclassical model, with the main differences being (i) the addition of nominal rigidities in the form monopolistically competitive producers of differentiated varieties that are subject to quadratic costs of price adjustment, (ii) the addition of a central bank that follows a standard Taylor rule, and (iii) the exclusion of physical capital for computational tractability.

**Households** Households are ex-ante heterogeneous with respect to their discount factor $\beta_i \in \{\beta_1, \beta_2, \beta_3\}$ and choose how much to consume, $c$, work, $n$, and save, $b'$, in order to maximize the same period utility function, subject to the same budget constraint as before. Note that savings are expressed in real terms. Additionally, since monopolistically competitive firms make positive profits at the stationary equilibrium, we assume that they are equally distributed across households in a lump-sum manner, $d_t$. The problem of the household can be written as:

$$
\begin{aligned}
&V(b,\beta,u) = \max_{c,n,b'} \left\{ \frac{c^{(1-\sigma)}}{1-\sigma} - \chi \frac{n^{(1+\eta)}}{1+\eta} + \beta \mathbf{E}_{u'} V(b',\beta,u') \right\} \\
&c + b' = (1+r)b + (1-\tau_l)wnu + g + d \\
&b' \geq \underline{b}
\end{aligned}
\tag{9}
$$

**Firms** A competitive final goods firm aggregates a continuum of intermediate goods indexed by $j$ with a constant elasticity of substitution $\mu/(\mu-1) > 1$. Intermediate goods are produced by monopolistically competitive firms with a linear production function:

$$y_i = F(n_j) \equiv n_j$$

Each firm sets the price of its product $p_j'$ subject to quadratic adjustment costs, with $\kappa$ moderating the extent of price rigidity. As $\kappa \to \infty$, we approach flexible prices:

$$\psi(p',p) = \frac{\mu}{\mu-1}\frac{1}{2\kappa}[\log(p'/p)]^2 Y$$

The firm's value function is given by

$$
\begin{aligned}
V(p) &= \max_{p'} \left\{ \frac{p'}{p} y - wy - \frac{\mu}{\mu-1}\frac{1}{2\kappa}[\log(p'/p]^2 Y + \mathbb{E}\left[\frac{V(p')}{1+r'}\right] \right\} \\
\text{s.t.} \qquad y &= \left(\frac{p'}{p}\right)^{-\frac{\mu}{\mu-1}} Y
\end{aligned}
$$

The first-order condition of the firm's problem plus the assumption that firms adopt symmetric pricing strategies give rise to a New Keynesian Phillips curve that relates aggregate output to price inflation:

$$\log(1+\pi) + \kappa\left(\frac{1}{\mu} - w\right) = \mathbb{E}\left[\frac{1}{1+r'}\frac{Y'}{Y}\log(1+\pi')\right]$$

Households receive dividends from the ownership of firms, and dividends equal output net of labor and price adjustment costs: $d = Y - wL - \psi$

**Fiscal and Monetary Policies** For simplicity, we assume that government debt is denominated in real terms. The government budget constraint is given by

$$\tau_l wN + B = (1 + r)B_{-1} + G + g$$

In the case of balanced budget experiments, we assume that lump-sum transfers adjust to keep the real stock of debt constant. In the case of deficit-financed changes in spending, we assume that lump-sum transfers follow a simple fiscal rule of the type

$$g = g_{ss} + \phi_T \left( \frac{B_{-1}}{B_{ss}} - 1 \right) \tag{10}$$

The monetary authority sets the nominal interest following a standard Taylor rule:

$$i = r^* + \phi_\pi \pi$$

where $r^*$ is the real interest rate target, $\pi_t$ is the inflation rate, and $\phi_\pi$ is the inflation Taylor rule coefficient. For simplicity, we assume that the central bank's inflation target is zero (and so the nominal and real rate targets coincide).

### *G.2 Equilibrium*

The equilibrium is defined in a manner that is similar to that of the neoclassical model. Given a distribution of agents $\Phi$, a competitive equilibrium with symmetric price-setting choices can be summarized as follows:

1. Taking a sequence of factor prices and initial conditions as given, households maximize the value function $V(b, \beta, u)$ with the respective policy functions being given by $c(b, \beta, u)$, $n(b, \beta, u)$, and $b'(b, \beta, u)$.

2. Firms optimally choose sequences of prices, production, and employment.

3. Fiscal and monetary authorities follow fiscal and interest rate rules.

4. Markets clear:

$$B = \int b \mathrm{d}\Phi$$
$$N = \int n(b, \beta, u) u \mathrm{d}\Phi$$
$$Y = \int c(b, \beta, u) \mathrm{d}\Phi + G + \psi$$

### *G.3 Calibration*

The calibration of the HANK model is kept as close as possible to that of the neoclassical model. There are two sets of parameters that we change: the first set is parameters unique to the New Keynesian model, and the second set is parameters that are recalibrated to match certain targets.

**New Keynesian parameters** The NK features of the HANK model add a few parameters that are not present in the neoclassical model. We use similar parameter values to those of Auclert et al. (2021b): the degree of price rigidity is set to $\kappa = 0.1$ and the elasticity of substitution between varieties is set to target a steady state markup of 20%, $\mu = 1.2$. The central bank's sensitivity to deviations of inflation from its target is set to $\phi_\pi = 1.25$.

**Internally calibrated parameters** We internally recalibrate a series of parameters in order to match some of the same targets we consider in the neoclassical model at the stationary equilibrium: the discount factors $\{\beta_1, \beta_2, \beta_3\}$, the borrowing limit $b$, the disutility of labor $\chi$, and the variance of the idiosyncratic component of log earnings $\sigma_\epsilon$. These parameters are calibrated to match the three quartiles of the wealth distribution, the level of the real interest rate, the aggregate fraction of hours worked, and the annual variance of log wages. Table 21 summarizes the values for the endogenously calibrated parameters, and table 22 presents the model fit.

| Parameter | Value | Description |
|---|---|---|
| $\beta_1, \beta_2, \beta_3$ | 0.9798, 0.9800, 0.9798 | Discount factors |
| $\underline{b}$ | 0.163 | Borrowing limit |
| $\sigma_e$ | 0.340 | Cross-sectional std of log earnings |
| $\chi$ | 12.463 | Disutility of labor |

**Table 21:** Internally calibrated parameters, HANK model

| Data moment | Description | Source | Data | Model |
|---|---|---|---|---|
| $\text{Var}(\ln w)$ | Yearly variance of log wages | LIS | 0.509 | 0.509 |
| $\bar{n}$ | Fraction of hours worked | OECD | 0.248 | 0.248 |
| $Q_{25}, Q_{50}, Q_{75}$ | Wealth quartiles | LWS | -0.014, 0.004, 0.120 | -0.013, 0.004, 0.238 |
| $r$ | Real interest rate | Neoclassical model | 0.0115 | 0.0115 |

**Table 22:** Model fit, HANK